



US010687887B2

(12) **United States Patent**  
**Dycus et al.**

(10) **Patent No.:** **US 10,687,887 B2**  
(45) **Date of Patent:** **Jun. 23, 2020**

(54) **VESSEL SEALER AND DIVIDER**  
(71) Applicant: **COVIDEN AG**, Neuhausen am Rheinfall (CH)  
(72) Inventors: **Sean T. Dycus**, Zurich (CH); **Steven P. Buysse**, Niwot, CO (US); **Dax D. Brown**, Bardstown, KY (US)  
(73) Assignee: **Covidien AG**, Neuhausen am (CH)  
(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(56) **References Cited**  
U.S. PATENT DOCUMENTS  
371,664 A 10/1887 Brannan et al.  
702,472 A 6/1902 Pignolet  
(Continued)

**FOREIGN PATENT DOCUMENTS**

CA 2104423 A1 2/1994  
CA 2520413 A1 3/2007  
(Continued)

**OTHER PUBLICATIONS**

LigaSure Vessel Sealing System, the Seal of Confidence in General, Gynecologic, Urologic, and Laparoscopic Surgery Sales/Product Literature; Jan. 2004.

(Continued)

*Primary Examiner* — Daniel W Fowler

*Assistant Examiner* — Tigist S Demie

(74) *Attorney, Agent, or Firm* — Carter, DeLuca & Farrell LLP

(21) Appl. No.: **16/391,210**  
(22) Filed: **Apr. 22, 2019**  
(65) **Prior Publication Data**  
US 2019/0247111 A1 Aug. 15, 2019

**Related U.S. Application Data**

(63) Continuation of application No. 16/053,052, filed on Aug. 2, 2018, now Pat. No. 10,265,121, which is a (Continued)

(51) **Int. Cl.**  
**A61B 18/14** (2006.01)  
**A61B 90/00** (2016.01)  
(Continued)

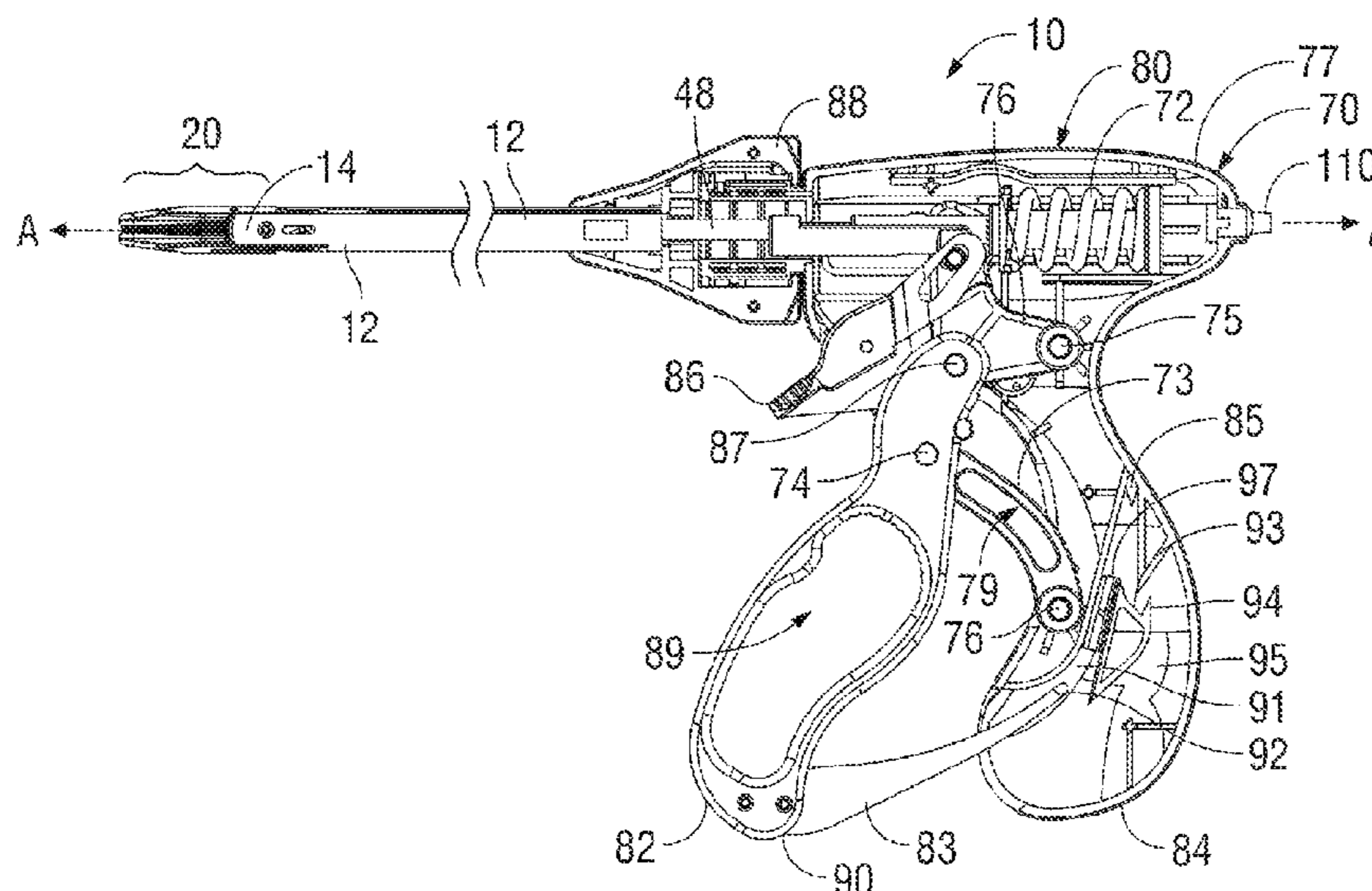
(52) **U.S. Cl.**  
CPC ..... **A61B 18/1445** (2013.01); **A61B 18/1482** (2013.01); **A61B 90/03** (2016.02);  
(Continued)

(58) **Field of Classification Search**  
CPC . A61B 17/32; A61B 18/1206; A61B 18/1445; A61B 18/1482;  
(Continued)

(57) **ABSTRACT**

A bipolar forceps includes an elongated shaft having opposing jaw members at a distal end thereof. The jaw members are movable relative to one another from a first position wherein the jaw members are disposed in spaced relation relative to one another to a second position wherein the jaw members cooperate to grasp tissue therebetween. The jaws members are connected to a source of electrical energy such that the jaw members are capable of conducting energy through tissue held therebetween to effect a tissue seal. At least one non-conductive and spaced-apart stop member is disposed on an inner-facing surface of the jaw members to regulate the gap distance between the jaw members when tissue is held therebetween. The forceps also includes a longitudinally reciprocating knife which severs the tissue after sealing at a location which is proximate the sealing site.

**13 Claims, 6 Drawing Sheets**



**Related U.S. Application Data**

continuation of application No. 15/911,739, filed on Mar. 5, 2018, now Pat. No. 10,251,696, which is a continuation of application No. 15/338,663, filed on Oct. 31, 2016, now abandoned, which is a continuation of application No. 14/719,887, filed on May 22, 2015, now abandoned, which is a continuation of application No. 13/584,194, filed on Aug. 13, 2012, now abandoned, which is a continuation of application No. 12/348,748, filed on Jan. 5, 2009, now Pat. No. 8,241,284, which is a continuation of application No. 10/471,818, filed as application No. PCT/US01/11413 on Apr. 6, 2001, now Pat. No. 7,473,253.

(51) **Int. Cl.**

*A61B 17/32* (2006.01)  
*A61B 17/29* (2006.01)  
*A61B 18/00* (2006.01)  
*A61B 18/12* (2006.01)  
*A61B 18/18* (2006.01)  
*A61B 17/00* (2006.01)

(52) **U.S. Cl.**

CPC ..... *A61B 17/32* (2013.01); *A61B 18/1206* (2013.01); *A61B 2017/00539* (2013.01); *A61B 2017/2926* (2013.01); *A61B 2018/0063* (2013.01); *A61B 2018/00077* (2013.01); *A61B 2018/00178* (2013.01); *A61B 2018/00196* (2013.01); *A61B 2018/00404* (2013.01); *A61B 2018/126* (2013.01); *A61B 2018/1412* (2013.01); *A61B 2018/1455* (2013.01); *A61B 2018/1861* (2013.01); *A61B 2090/034* (2016.02)

(58) **Field of Classification Search**

CPC .. *A61B 2017/00539*; *A61B 2017/2926*; *A61B 2018/00077*; *A61B 2018/00178*; *A61B 2018/00196*; *A61B 2018/00404*; *A61B 2018/0063*; *A61B 2018/126*; *A61B 2018/1412*; *A61B 2018/1455*; *A61B 2018/1861*; *A61B 2090/034*; *A61B 90/03*  
 See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

728,883 A 5/1903 Downes  
 1,586,645 A 6/1926 Bierman  
 1,813,902 A 7/1931 Bovie  
 1,822,330 A 9/1931 Ainslie  
 1,852,542 A 4/1932 Sovatkin  
 1,908,201 A 5/1933 Welch et al.  
 1,918,889 A 7/1933 Bacon  
 2,002,594 A 5/1935 Wappler et al.  
 2,011,169 A 8/1935 Wappler et al.  
 2,031,682 A 2/1936 Wappler et al.  
 2,054,149 A 9/1936 Wappler  
 2,113,246 A 4/1938 Wappler  
 2,141,936 A 12/1938 Schmitt  
 2,176,479 A 10/1939 Willis  
 2,245,030 A 6/1941 Gottesfeld et al.  
 2,279,753 A 4/1942 Knopp  
 2,305,156 A 12/1942 Grubel  
 2,327,353 A 8/1943 Karle  
 2,632,661 A 3/1953 Cristofv  
 2,668,538 A 2/1954 Baker  
 2,796,065 A 6/1957 Kapp  
 2,824,915 A 2/1958 Buturuga  
 3,073,311 A 1/1963 Tibbs et al.  
 3,100,489 A 8/1963 Bagley  
 3,204,807 A 9/1965 Ramsing

3,372,288 A 3/1968 Wigington  
 3,459,187 A 8/1969 Pallotta  
 3,561,448 A 2/1971 Peternel  
 3,643,663 A 2/1972 Sutter  
 3,648,001 A 3/1972 Anderson et al.  
 3,651,811 A 3/1972 Hildebrandt et al.  
 3,678,229 A 7/1972 Osika  
 3,720,896 A 3/1973 Beierlein  
 3,763,726 A 10/1973 Hildebrand  
 3,779,918 A 12/1973 Ikeda et al.  
 3,798,688 A 3/1974 Wasson  
 3,801,766 A 4/1974 Morrison, Jr.  
 3,839,614 A 10/1974 Saganowski et al.  
 3,862,630 A 1/1975 Balamuth  
 3,863,339 A 2/1975 Reaney et al.  
 3,866,610 A 2/1975 Kletschka  
 3,875,945 A 4/1975 Friedman  
 3,897,786 A 8/1975 Garnett et al.  
 3,911,766 A 10/1975 Fridolph et al.  
 3,920,021 A 11/1975 Hildebrandt  
 3,921,641 A 11/1975 Hulka  
 3,938,527 A 2/1976 Rioux et al.  
 3,952,749 A 4/1976 Fridolph et al.  
 3,970,088 A 7/1976 Morrison  
 3,987,795 A 10/1976 Morrison  
 4,005,714 A 2/1977 Hildebrandt  
 4,016,881 A 4/1977 Rioux et al.  
 4,031,898 A 6/1977 Hildebrandt et al.  
 4,041,952 A 8/1977 Morrison, Jr. et al.  
 4,043,342 A 8/1977 Morrison, Jr.  
 4,074,718 A 2/1978 Morrison, Jr.  
 4,076,028 A 2/1978 Simmons  
 4,080,820 A 3/1978 Allen  
 4,088,134 A 5/1978 Mazzariello  
 4,102,471 A 7/1978 Lore et al.  
 D249,549 S 9/1978 Pike  
 4,112,950 A 9/1978 Pike  
 4,127,222 A 11/1978 Adams  
 4,128,099 A 12/1978 Bauer  
 4,165,746 A 8/1979 Burgin  
 4,187,420 A 2/1980 Piber  
 4,200,104 A 4/1980 Harris  
 4,200,105 A 4/1980 Gonser  
 4,233,734 A 11/1980 Bies  
 4,236,470 A 12/1980 Stenson  
 4,274,413 A 6/1981 Hahn et al.  
 4,300,564 A 11/1981 Furihata  
 4,306,561 A 12/1981 de Medinaceli  
 4,311,145 A 1/1982 Esty et al.  
 D263,020 S 2/1982 Rau, III  
 4,315,510 A 2/1982 Kihn  
 4,363,944 A 12/1982 Poirier  
 4,370,980 A 2/1983 Lottick  
 4,375,218 A 3/1983 DiGeronimo  
 4,394,552 A 7/1983 Schlosser  
 4,416,276 A 11/1983 Newton et al.  
 4,418,692 A 12/1983 Guay  
 4,443,935 A 4/1984 Zamba et al.  
 4,452,246 A 6/1984 Bader et al.  
 4,470,786 A 9/1984 Sano et al.  
 4,492,231 A 1/1985 Auth  
 4,493,320 A 1/1985 Treat  
 4,503,855 A 3/1985 Maslanka  
 4,506,669 A 3/1985 Blake, III  
 4,509,518 A 4/1985 McGarry et al.  
 4,513,271 A 4/1985 Reisem  
 4,535,773 A 8/1985 Yoon  
 4,552,143 A 11/1985 Lottick  
 4,574,804 A 3/1986 Kurwa  
 4,597,379 A 7/1986 Kihn et al.  
 4,600,007 A 7/1986 Lahodny et al.  
 4,619,258 A 10/1986 Pool  
 4,624,254 A 11/1986 McGarry et al.  
 4,625,723 A 12/1986 Altnether et al.  
 4,644,950 A 2/1987 Valli  
 4,655,215 A 4/1987 Pike  
 4,655,216 A 4/1987 Tischer  
 4,657,016 A 4/1987 Garito et al.  
 4,662,372 A 5/1987 Sharkany et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

4,671,274 A	6/1987	Sorochenko	5,277,201 A	1/1994	Stern
4,674,499 A	6/1987	Pao	5,281,220 A	1/1994	Blake, III
4,685,459 A	8/1987	Koch et al.	5,282,799 A	2/1994	Rydell
4,733,662 A	3/1988	DeSatnick et al.	5,282,800 A	2/1994	Foshee et al.
D295,893 S	5/1988	Sharkany et al.	5,282,826 A	2/1994	Quadri
D295,894 S	5/1988	Sharkany et al.	5,290,286 A	3/1994	Parins
4,753,235 A	6/1988	Hasson	5,290,287 A	3/1994	Boebel et al.
4,754,892 A	7/1988	Retief	5,300,082 A	4/1994	Shame et al.
4,761,175 A	8/1988	Schirmer et al.	5,304,203 A	4/1994	El-Mallawany et al.
4,763,669 A	8/1988	Jaeger	5,308,353 A	5/1994	Beurrier
D298,353 S	11/1988	Manno	5,308,357 A	5/1994	Lichtman
4,781,175 A	11/1988	McGreevy et al.	5,312,433 A	5/1994	Boebel et al.
D299,413 S	1/1989	DeCarolis	5,313,027 A	5/1994	Inoue et al.
4,805,616 A	2/1989	Pao	5,314,445 A	5/1994	Heidmueller et al.
4,827,927 A	5/1989	Newton	5,314,463 A	5/1994	Camps et al.
4,827,929 A	5/1989	Hodge	5,318,589 A	6/1994	Lichtman
4,829,313 A	5/1989	Taggart	5,324,289 A	6/1994	Eggers
4,846,171 A	7/1989	Kauphusman et al.	D348,930 S	7/1994	Olson
4,887,612 A	12/1989	Esser et al.	5,326,806 A	7/1994	Yokoshima et al.
4,890,610 A	1/1990	Kirwan, Sr. et al.	5,330,471 A	7/1994	Eggers
4,938,761 A	7/1990	Ensslin	5,330,502 A	7/1994	Hassler et al.
4,947,009 A	8/1990	Osika et al.	D349,341 S	8/1994	Lichtman et al.
4,973,801 A	11/1990	Frick et al.	5,334,166 A	8/1994	Palestrant
4,985,030 A	1/1991	Melzer et al.	5,334,183 A	8/1994	Wuchinich
5,007,908 A	4/1991	Rydell	5,334,215 A	8/1994	Chen
5,019,678 A	5/1991	Templeton et al.	5,336,220 A	8/1994	Ryan et al.
5,026,370 A	6/1991	Lottick	5,336,221 A	8/1994	Anderson
5,026,371 A	6/1991	Rydell et al.	5,342,359 A	8/1994	Rydell
5,035,695 A	7/1991	Weber, Jr. et al.	5,342,381 A	8/1994	Tidemand
5,037,433 A	8/1991	Wilk et al.	5,342,393 A	8/1994	Stack
5,042,707 A	8/1991	Taheri	5,344,424 A	9/1994	Roberts et al.
5,047,046 A	9/1991	Bodoia	5,350,391 A	9/1994	Iacovelli
5,052,402 A	10/1991	Bencini et al.	5,352,222 A	10/1994	Rydell
5,078,716 A	1/1992	Doll	5,354,271 A	10/1994	Voda
5,084,057 A	1/1992	Green et al.	5,356,408 A	10/1994	Rydell
5,085,659 A	2/1992	Rydell	5,359,993 A	11/1994	Slater et al.
5,099,840 A	3/1992	Goble et al.	5,366,477 A	11/1994	LeMarie, III et al.
5,100,430 A	3/1992	Avellanet et al.	5,367,250 A	11/1994	Whisenand
5,108,392 A	4/1992	Spingler	5,368,600 A	11/1994	Failla et al.
5,112,343 A	5/1992	Thornton	5,374,277 A	12/1994	Hassler
5,116,332 A	5/1992	Lottick	5,376,089 A	12/1994	Smith
5,122,139 A	6/1992	Sutter	5,376,094 A	12/1994	Kline
5,144,323 A	9/1992	Yonkers	D354,564 S	1/1995	Medema
5,147,357 A	9/1992	Rose et al.	5,383,875 A	1/1995	Bays et al.
5,151,102 A	9/1992	Kamiyama et al.	5,383,880 A	1/1995	Hooven
5,151,978 A	9/1992	Bronikowski et al.	5,383,897 A	1/1995	Wholey
5,158,561 A	10/1992	Rydell et al.	5,389,098 A	2/1995	Tsuruta et al.
5,169,396 A	12/1992	Dowlatshahi et al.	5,389,103 A	2/1995	Melzer et al.
5,176,695 A	1/1993	Dulebohn	5,389,104 A	2/1995	Hahnen et al.
5,176,702 A *	1/1993	Bales ..... A61B 17/2909 606/208	5,391,166 A	2/1995	Eggers
5,190,541 A	3/1993	Abele et al.	5,391,183 A	2/1995	Janzen et al.
5,196,009 A	3/1993	Kirwan, Jr.	5,395,360 A	3/1995	Manoukian
5,197,964 A	3/1993	Parins	5,396,194 A	3/1995	Williamson et al.
5,209,747 A	5/1993	Knoepfler	5,396,900 A	3/1995	Slater et al.
5,211,655 A	5/1993	Hasson	5,397,325 A	3/1995	Della Badia et al.
5,215,101 A	6/1993	Jacobs et al.	5,403,312 A	4/1995	Yates et al.
5,217,457 A	6/1993	Delahuerga et al.	5,403,342 A	4/1995	Tovey et al.
5,217,458 A	6/1993	Parins	5,405,344 A	4/1995	Williamson et al.
5,217,460 A	6/1993	Knoepfler	5,409,763 A	4/1995	Serizawa et al.
5,219,354 A	6/1993	Choudhury et al.	D358,887 S	5/1995	Feinberg
5,231,997 A	8/1993	Kikuchi et al.	5,411,519 A	5/1995	Tovey et al.
5,244,462 A	9/1993	Delahuerga et al.	5,411,520 A	5/1995	Nash et al.
5,250,047 A	10/1993	Rydell	5,413,571 A	5/1995	Katsaros et al.
5,250,056 A	10/1993	Hasson	5,415,656 A	5/1995	Tihon et al.
5,250,063 A	10/1993	Abidin et al.	5,415,657 A	5/1995	Taymor-Luria
5,254,129 A	10/1993	Alexander	5,417,709 A	5/1995	Slater
5,258,001 A	11/1993	Corman	5,422,567 A	6/1995	Matsunaga
5,258,006 A	11/1993	Rydell et al.	5,423,810 A	6/1995	Goble et al.
5,261,918 A	11/1993	Phillips et al.	5,425,690 A	6/1995	Chang
5,267,998 A	12/1993	Hagen	5,425,739 A	6/1995	Jessen
5,269,780 A	12/1993	Roos	5,429,616 A	7/1995	Schaffer
5,269,804 A	12/1993	Bales et al.	5,431,672 A	7/1995	Cote et al.
D343,453 S	1/1994	Noda	5,431,674 A	7/1995	Basile et al.
5,275,615 A	1/1994	Rose	5,437,277 A	8/1995	Dumoulin et al.
			5,437,292 A	8/1995	Kipshidze et al.
			5,438,302 A	8/1995	Goble
			5,439,478 A	8/1995	Palmer
			5,441,517 A	8/1995	Kensey et al.
			5,443,463 A	8/1995	Stern et al.

(56)

## References Cited

## U.S. PATENT DOCUMENTS

5,443,464 A	8/1995	Russell et al.	5,601,641 A	2/1997	Stephens
5,443,479 A	8/1995	Bressi, Jr.	5,603,711 A	2/1997	Parins et al.
5,443,480 A	8/1995	Jacobs et al.	5,603,723 A	2/1997	Aranyi et al.
5,445,622 A	8/1995	Brown	5,607,436 A	3/1997	Pratt et al.
5,445,638 A	8/1995	Rydell et al.	5,611,798 A	3/1997	Eggers
5,445,658 A	8/1995	Durrfeld et al.	5,611,808 A	3/1997	Hossain et al.
5,449,480 A	9/1995	Kuriya	5,611,813 A	3/1997	Lichtman
5,451,224 A	9/1995	Goble et al.	5,618,294 A	4/1997	Aust et al.
5,454,739 A	10/1995	Strand	5,618,307 A	4/1997	Donlon et al.
5,454,809 A	10/1995	Janssen	5,620,415 A	4/1997	Lucey et al.
5,454,823 A	10/1995	Richardson et al.	5,620,453 A	4/1997	Nallakrishnan
5,454,827 A	10/1995	Aust et al.	5,620,459 A	4/1997	Lichtman
5,456,684 A	10/1995	Schmidt et al.	5,624,281 A	4/1997	Christensson
5,458,598 A	10/1995	Feinberg et al.	5,624,452 A	4/1997	Yates
5,460,629 A	10/1995	Shlain et al.	5,626,578 A	5/1997	Tihon
5,461,765 A	10/1995	Linden et al.	5,626,607 A	5/1997	Malecki et al.
5,462,546 A	10/1995	Rydell	5,626,609 A	5/1997	Zvenyatsky et al.
5,466,243 A *	11/1995	Schmieding ..... A61F 2/0805 606/232	5,630,833 A	5/1997	Katsaros et al.
5,472,442 A	12/1995	Kliccek	5,637,110 A	6/1997	Pennybacker et al.
5,472,443 A	12/1995	Cordis et al.	5,637,111 A	6/1997	Sutcu et al.
5,476,479 A	12/1995	Green et al.	5,638,003 A	6/1997	Hall
5,478,351 A	12/1995	Meade et al.	5,638,827 A	6/1997	Palmer et al.
5,480,406 A	1/1996	Nolan et al.	5,639,403 A	6/1997	Ida et al.
5,480,409 A	1/1996	Riza	5,643,294 A	7/1997	Tovey et al.
5,482,054 A	1/1996	Slater et al.	5,647,869 A	7/1997	Goble et al.
5,484,436 A	1/1996	Eggers et al.	5,647,871 A	7/1997	Levine et al.
5,493,899 A	2/1996	Beck et al.	5,649,959 A	7/1997	Hannam et al.
5,496,312 A	3/1996	Kliccek	5,655,650 A	8/1997	Naitou
5,496,317 A	3/1996	Goble et al.	5,658,281 A	8/1997	Heard
5,496,347 A	3/1996	Hashiguchi et al.	D384,413 S	9/1997	Zlock et al.
5,499,997 A	3/1996	Sharpe et al.	5,662,667 A	9/1997	Knodel
5,501,654 A	3/1996	Failla et al.	5,665,100 A	9/1997	Yoon
5,509,922 A	4/1996	Aranyi et al.	5,667,526 A	9/1997	Levin
5,512,721 A	4/1996	Young et al.	5,673,841 A	10/1997	Schulze et al.
5,514,134 A	5/1996	Rydell et al.	5,674,220 A	10/1997	Fox et al.
5,520,702 A	5/1996	Sauer et al.	5,674,229 A	10/1997	Tovey et al.
5,527,313 A	6/1996	Scott et al.	5,681,282 A	10/1997	Eggers et al.
5,528,833 A	6/1996	Sakuma	5,688,270 A	11/1997	Yates et al.
5,529,067 A	6/1996	Larsen et al.	5,690,652 A	11/1997	Wurster et al.
5,531,744 A	7/1996	Nardella et al.	5,690,653 A	11/1997	Richardson et al.
5,536,251 A	7/1996	Evard et al.	5,693,051 A *	12/1997	Schulze ..... A61B 17/07207 606/51
5,540,684 A	7/1996	Hassler, Jr.	5,693,920 A	12/1997	Maeda
5,540,685 A	7/1996	Parins et al.	5,695,522 A	12/1997	LeMaire, III et al.
5,540,706 A	7/1996	Aust et al.	5,700,261 A	12/1997	Brinkerhoff
5,540,715 A	7/1996	Katsaros et al.	5,700,270 A	12/1997	Peysen et al.
5,542,945 A	8/1996	Fritsch	5,702,390 A	12/1997	Austin et al.
5,549,604 A	8/1996	Sutcu et al.	5,707,369 A	1/1998	Vaitekunas et al.
5,554,172 A	9/1996	Horner et al.	5,709,680 A	1/1998	Yates et al.
5,558,671 A	9/1996	Yates	5,713,895 A	2/1998	Lontine et al.
5,558,672 A	9/1996	Edwards et al.	5,716,366 A	2/1998	Yates
5,562,619 A	10/1996	Mirarchi et al.	5,720,742 A	2/1998	Zacharias
5,562,699 A	10/1996	Heimberger et al.	5,720,744 A	2/1998	Eggleston et al.
5,562,720 A	10/1996	Stern et al.	5,722,421 A	3/1998	Francese et al.
5,564,615 A	10/1996	Bishop et al.	5,725,536 A	3/1998	Oberlin et al.
5,568,859 A	10/1996	Levy et al.	5,727,428 A	3/1998	LeMaire, III et al.
5,569,241 A	10/1996	Edwards	5,735,848 A	4/1998	Yates et al.
5,569,243 A	10/1996	Kortenbach et al.	5,735,849 A	4/1998	Baden et al.
5,571,100 A	11/1996	Goble et al.	5,743,906 A	4/1998	Parins et al.
5,573,424 A	11/1996	Poppe	5,752,973 A	5/1998	Kieturakis
5,573,534 A	11/1996	Stone	5,755,717 A	5/1998	Yates et al.
5,573,535 A	11/1996	Viklund	5,759,188 A	6/1998	Yoon
5,575,799 A	11/1996	Bolanos et al.	5,762,255 A	6/1998	Chrisman et al.
5,575,805 A	11/1996	Li	5,762,609 A	6/1998	Benaron et al.
5,578,052 A	11/1996	Koros et al.	5,766,130 A	6/1998	Selmonosky
5,579,781 A	12/1996	Cooke	5,766,166 A	6/1998	Hooven
5,582,611 A	12/1996	Tsuruta et al.	5,766,170 A	6/1998	Eggers
5,582,617 A	12/1996	Klieman et al.	5,766,196 A	6/1998	Griffiths
5,585,896 A	12/1996	Yamazaki et al.	5,769,849 A	6/1998	Eggers
5,590,570 A	1/1997	LeMaire, III et al.	5,772,655 A	6/1998	Bauer et al.
5,591,181 A	1/1997	Stone et al.	5,772,670 A	6/1998	Brosa
5,597,107 A	1/1997	Knodel et al.	5,776,128 A	7/1998	Eggers
5,599,350 A	2/1997	Schulze et al.	5,776,130 A	7/1998	Buysse et al.
5,601,224 A	2/1997	Bishop et al.	5,776,156 A	7/1998	Shikhman
5,601,601 A	2/1997	Tal et al.	5,777,519 A	7/1998	Simopoulos
			5,779,646 A	7/1998	Koblish et al.
			5,779,701 A	7/1998	McBrayer et al.
			5,779,727 A	7/1998	Orejola
			5,781,048 A	7/1998	Nakao et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

H1745 H	8/1998	Paraschac	5,951,549 A	9/1999	Richardson et al.
5,791,231 A	8/1998	Cohn et al.	5,954,720 A	9/1999	Wilson et al.
5,792,137 A	8/1998	Carr et al.	5,954,731 A	9/1999	Yoon
5,792,165 A	8/1998	Klieman et al.	5,954,733 A	9/1999	Yoon
5,792,177 A	8/1998	Kaseda	5,957,923 A	9/1999	Hahnen et al.
5,797,537 A	8/1998	Oberlin et al.	5,957,937 A	9/1999	Yoon
5,797,927 A	8/1998	Yoon	5,960,544 A	10/1999	Beyers
5,797,938 A	8/1998	Paraschac et al.	5,961,514 A	10/1999	Long et al.
5,797,941 A	8/1998	Schulze et al.	5,964,758 A	10/1999	Dresden
5,797,958 A	8/1998	Yoon	5,967,997 A	10/1999	Turturro et al.
5,797,959 A	8/1998	Castro et al.	D416,089 S	11/1999	Barton et al.
5,800,448 A	9/1998	Banko	5,976,132 A	11/1999	Morris
5,800,449 A	9/1998	Wales	5,984,932 A	11/1999	Yoon
5,807,393 A	9/1998	Williamson, IV et al.	5,984,938 A	11/1999	Yoon
5,810,764 A	9/1998	Eggers et al.	5,984,939 A	11/1999	Yoon
5,810,805 A	9/1998	Sutcu et al.	5,989,277 A	11/1999	LeMaire, III et al.
5,810,808 A	9/1998	Eggers	5,993,466 A	11/1999	Yoon
5,810,811 A	9/1998	Yates et al.	5,993,467 A	11/1999	Yoon
5,810,877 A	9/1998	Roth et al.	5,993,474 A	11/1999	Ouchi
5,814,043 A	9/1998	Shapeton	5,997,565 A	12/1999	Inoue
5,814,054 A	9/1998	Kortenbach et al.	6,003,517 A	12/1999	Sheffield et al.
5,817,083 A	10/1998	Shemesh et al.	6,004,332 A	12/1999	Yoon et al.
5,817,119 A	10/1998	Klieman et al.	6,004,335 A	12/1999	Vaitekunas et al.
5,820,630 A	10/1998	Lind	6,010,516 A	1/2000	Hulka
5,824,978 A	10/1998	Karasik et al.	6,010,519 A	1/2000	Mawhirt et al.
5,827,271 A	10/1998	Buyse et al.	6,017,354 A	1/2000	Culp et al.
5,827,274 A	10/1998	Bonnet et al.	6,017,358 A	1/2000	Yoon et al.
5,827,279 A	10/1998	Hughett et al.	6,021,693 A	2/2000	Feng-Sing
5,827,281 A	10/1998	Levin	6,024,741 A	2/2000	Williamson, IV et al.
5,827,323 A	10/1998	Klieman et al.	6,024,743 A	2/2000	Edwards
5,827,548 A	10/1998	Lavallee et al.	6,024,744 A	2/2000	Kese et al.
5,830,212 A	11/1998	Cartmell et al.	6,027,522 A	2/2000	Palmer
5,833,690 A	11/1998	Yates et al.	6,027,522 A	2/2000	Palmer
5,833,695 A	11/1998	Yoon	6,030,384 A	2/2000	Nezhat
5,836,072 A	11/1998	Sullivan et al.	6,033,399 A	3/2000	Gines
D402,028 S	12/1998	Grimm et al.	6,039,733 A	3/2000	Buyse et al.
5,843,080 A	12/1998	Fleenor et al.	6,041,679 A	3/2000	Slater et al.
5,849,020 A	12/1998	Long et al.	6,050,995 A	4/2000	Durgin
5,849,022 A	12/1998	Sakashita et al.	6,050,996 A	4/2000	Schmaltz et al.
5,851,214 A	12/1998	Larsen et al.	6,053,914 A	4/2000	Eggers et al.
5,853,412 A	12/1998	Mayenberger	6,053,933 A	4/2000	Balazs et al.
5,859,527 A	1/1999	Cook	D424,694 S	5/2000	Tetzlaff et al.
5,860,976 A	1/1999	Billings et al.	D425,201 S	5/2000	Tetzlaff et al.
5,865,361 A	2/1999	Milliman et al.	6,056,735 A	5/2000	Okada et al.
5,876,401 A	3/1999	Schulze et al.	6,059,782 A	5/2000	Novak et al.
5,876,410 A	3/1999	Petillo	6,063,086 A	5/2000	Benecke et al.
5,876,412 A	3/1999	Piraka	6,063,103 A	5/2000	Hashiguchi
5,882,567 A	3/1999	Cavallaro et al.	6,066,137 A	5/2000	Greep
D408,018 S	4/1999	McNaughton	6,066,139 A	5/2000	Ryan et al.
5,891,141 A	4/1999	Rydell	6,071,283 A	6/2000	Nardella et al.
5,891,142 A *	4/1999	Eggers ..... A61B 18/1442 606/51	6,074,386 A	6/2000	Goble et al.
5,893,848 A	4/1999	Negus et al.	6,077,287 A	6/2000	Taylor et al.
5,893,863 A	4/1999	Yoon	6,080,180 A	6/2000	Yoon et al.
5,893,875 A	4/1999	O'Connor et al.	RE36,795 E	7/2000	Rydell
5,893,877 A	4/1999	Gampp, Jr. et al.	6,083,150 A	7/2000	Aznoian et al.
5,897,563 A	4/1999	Yoon et al.	6,083,223 A	7/2000	Baker
5,902,301 A	5/1999	Olig	6,086,586 A *	7/2000	Hooven ..... A61B 18/1442 606/48
5,906,630 A	5/1999	Anderhub et al.	6,086,601 A	7/2000	Yoon
5,907,140 A	5/1999	Smith	6,090,107 A	7/2000	Borgmeier et al.
5,908,420 A	6/1999	Parins et al.	6,090,123 A	7/2000	Culp et al.
5,908,432 A	6/1999	Pan	6,096,031 A	8/2000	Mitchell et al.
5,911,719 A	6/1999	Eggers	6,096,037 A	8/2000	Mulier et al.
5,913,874 A	6/1999	Berns et al.	6,099,537 A	8/2000	Sugai et al.
5,921,916 A	7/1999	Aeikens et al.	6,099,550 A	8/2000	Yoon
5,921,984 A	7/1999	Sutcu et al.	6,102,909 A	8/2000	Chen et al.
5,925,043 A	7/1999	Kumar et al.	6,106,542 A	8/2000	Toybin et al.
5,928,136 A	7/1999	Barry	6,110,171 A	8/2000	Rydell
5,935,126 A	8/1999	Riza	6,113,596 A	9/2000	Hooven et al.
5,938,589 A	8/1999	Wako et al.	6,113,598 A	9/2000	Baker
5,941,869 A	8/1999	Patterson et al.	6,117,158 A	9/2000	Measamer et al.
5,944,562 A	8/1999	Christensson	6,122,549 A	9/2000	Sharkey et al.
5,944,718 A	8/1999	Austin et al.	6,123,701 A	9/2000	Nezhat
5,951,545 A	9/1999	Schilling et al.	H1904 H	10/2000	Yates et al.
5,951,546 A	9/1999	Lorentzen	6,126,658 A	10/2000	Baker
			6,126,665 A	10/2000	Yoon
			6,139,563 A	10/2000	Cosgrove, III et al.
			6,143,005 A	11/2000	Yoon et al.
			6,152,923 A	11/2000	Ryan
			6,152,924 A	11/2000	Parins

(56)

## References Cited

## U.S. PATENT DOCUMENTS

6,159,217	A	12/2000	Robie et al.	6,440,130	B1	8/2002	Mulier et al.
6,162,220	A	12/2000	Nezhat	6,440,144	B1	8/2002	Bacher
6,171,316	B1	1/2001	Kovac et al.	6,443,952	B1	9/2002	Mulier et al.
6,174,309	B1	1/2001	Wrublewski et al.	6,443,970	B1	9/2002	Schulze et al.
6,174,310	B1	1/2001	Kirwan, Jr.	6,451,018	B1	9/2002	Lands et al.
6,178,628	B1	1/2001	Clemens et al.	6,458,125	B1	10/2002	Cosmescu
6,179,834	B1	1/2001	Buysse et al.	6,458,128	B1	10/2002	Schulze
6,179,837	B1	1/2001	Hooven	6,458,129	B2	10/2002	Scarti
6,183,467	B1	2/2001	Shapeton et al.	6,458,130	B1	10/2002	Frazier et al.
6,187,003	B1	2/2001	Buysse et al.	6,461,352	B2	10/2002	Morgan et al.
6,190,386	B1	2/2001	Rydell	6,461,368	B2	10/2002	Fogarty et al.
6,190,399	B1	2/2001	Palmer et al.	6,464,701	B1	10/2002	Hooven et al.
6,190,400	B1	2/2001	Van De Moer et al.	6,464,702	B2	10/2002	Schulze et al.
6,193,709	B1	2/2001	Miyawaki et al.	6,464,704	B2	10/2002	Schmaltz et al.
6,193,718	B1	2/2001	Kortenbach et al.	6,471,696	B1	10/2002	Berube et al.
6,206,876	B1	3/2001	Levine et al.	D465,281	S	11/2002	Lang
6,206,877	B1	3/2001	Kese et al.	D466,209	S	11/2002	Bon
6,206,893	B1	3/2001	Klein et al.	6,485,489	B2	11/2002	Teirstein et al.
6,214,028	B1	4/2001	Yoon et al.	6,488,680	B1	12/2002	Francischelli et al.
6,217,602	B1	4/2001	Redmon	6,494,882	B1	12/2002	Leboutitz et al.
6,217,615	B1	4/2001	Sioshansi et al.	6,494,888	B1	12/2002	Laufer et al.
6,221,039	B1	4/2001	Durgin et al.	6,500,176	B1	12/2002	Truckai et al.
6,223,100	B1	4/2001	Green	6,503,248	B1	1/2003	Levine
6,224,593	B1	5/2001	Ryan et al.	6,506,189	B1	1/2003	Rittman, III et al.
6,224,614	B1	5/2001	Yoon	6,506,196	B1	1/2003	Laufer
6,228,080	B1	5/2001	Gines	6,508,815	B1	1/2003	Strul et al.
6,228,083	B1	5/2001	Lands et al.	6,511,480	B1	1/2003	Tetzlaff et al.
6,248,124	B1	6/2001	Pedros et al.	6,514,215	B1	2/2003	Ouchi
6,248,944	B1	6/2001	Ito	6,514,251	B1	2/2003	Ni et al.
6,249,706	B1	6/2001	Sobota et al.	6,514,252	B2	2/2003	Nezhat et al.
6,261,307	B1	7/2001	Yoon et al.	6,517,536	B2	2/2003	Hooven et al.
6,267,758	B1	7/2001	Daw et al.	6,517,539	B1	2/2003	Smith et al.
6,267,761	B1	7/2001	Ryan	6,527,771	B1	3/2003	Weadock et al.
6,270,497	B1	8/2001	Sekino et al.	6,533,784	B2	3/2003	Truckai et al.
6,270,508	B1	8/2001	Klieman et al.	6,537,272	B2	3/2003	Christopherson et al.
6,273,887	B1	8/2001	Yamauchi et al.	6,540,745	B1	4/2003	Fairbourn et al.
6,277,117	B1	8/2001	Tetzlaff et al.	6,544,264	B2	4/2003	Levine et al.
6,280,458	B1	8/2001	Boche et al.	6,545,239	B2	4/2003	Spedale et al.
6,283,961	B1	9/2001	Underwood et al.	6,554,829	B2	4/2003	Schulze et al.
D449,886	S	10/2001	Tetzlaff et al.	6,554,844	B2	4/2003	Lee et al.
6,298,550	B1	10/2001	Kirwan, Jr.	6,558,385	B1	5/2003	McClurken et al.
6,302,424	B1	10/2001	Gisinger et al.	6,562,037	B2	5/2003	Paton et al.
6,303,166	B1	10/2001	Kolbe et al.	6,569,105	B1	5/2003	Kortenbach et al.
6,309,404	B1	10/2001	Krzyzanowski	6,569,162	B2	5/2003	He
6,319,262	B1	11/2001	Bates et al.	6,582,450	B2	6/2003	Ouchi
6,319,451	B1	11/2001	Brune	6,585,735	B1	7/2003	Frazier et al.
6,322,561	B1	11/2001	Eggers et al.	6,602,252	B2	8/2003	Mollenauer
6,322,580	B1	11/2001	Kanner	6,605,790	B2	8/2003	Yoshida
6,325,795	B1	12/2001	Lindemann et al.	6,610,060	B2	8/2003	Mulier et al.
6,329,778	B1	12/2001	Culp et al.	6,613,048	B2	9/2003	Mulier et al.
6,334,860	B1	1/2002	Dorn	6,616,654	B2	9/2003	Mollenauer
6,334,861	B1	1/2002	Chandler et al.	6,616,658	B2	9/2003	Ineson
D453,923	S	2/2002	Olson	6,616,661	B2	9/2003	Wellman et al.
6,345,532	B1	2/2002	Coudray et al.	6,620,161	B2	9/2003	Schulze et al.
6,350,264	B1	2/2002	Hooven	6,620,184	B2	9/2003	de Laforcade et al.
D454,951	S	3/2002	Bon	6,623,482	B2	9/2003	Pendekanti et al.
6,352,536	B1	3/2002	Buysse et al.	6,626,901	B1	9/2003	Treat et al.
6,358,249	B1	3/2002	Chen et al.	6,626,929	B1	9/2003	Bannerman
6,358,259	B1	3/2002	Swain et al.	6,629,534	B1	10/2003	St. Goar et al.
6,358,268	B1	3/2002	Hunt et al.	6,638,287	B2	10/2003	Danitz et al.
6,361,534	B1	3/2002	Chen et al.	6,641,595	B1	11/2003	Moran et al.
6,364,876	B1	4/2002	Erb et al.	6,652,514	B2	11/2003	Ellman et al.
6,364,879	B1	4/2002	Chen et al.	6,652,518	B2	11/2003	Wellman et al.
D457,958	S	5/2002	Dycus et al.	6,652,521	B2	11/2003	Schulze
D457,959	S	5/2002	Tetzlaff et al.	6,656,173	B1	12/2003	Palermo
6,385,265	B1	5/2002	Duffy et al.	6,656,175	B2	12/2003	Francischelli et al.
6,387,094	B1	5/2002	Eitenmuller	6,656,177	B2	12/2003	Truckai et al.
6,391,035	B1	5/2002	Appleby et al.	6,660,072	B2	12/2003	Chatterjee
6,398,779	B1	6/2002	Buysse et al.	6,663,639	B1	12/2003	Laufer et al.
6,402,747	B1	6/2002	Lindemann et al.	6,663,641	B1	12/2003	Kovac et al.
6,409,728	B1	6/2002	Ehr et al.	6,666,854	B1	12/2003	Lange
H2037	H	7/2002	Yates et al.	6,666,862	B2	12/2003	Jain et al.
6,419,675	B1	7/2002	Gallo, Sr.	6,669,696	B2	12/2003	Bacher et al.
6,425,896	B1	7/2002	Baltschun et al.	6,673,092	B1	1/2004	Bacher
6,432,112	B2	8/2002	Brock et al.	6,676,660	B2	1/2004	Wampler et al.
				6,676,676	B2	1/2004	Danitz et al.
				6,679,882	B1	1/2004	Komerup
				6,682,527	B2	1/2004	Strul
				6,682,528	B2	1/2004	Frazier et al.

(56)

## References Cited

## U.S. PATENT DOCUMENTS

6,685,704 B2	2/2004	Greep	6,960,210 B2	11/2005	Lands et al.
6,685,724 B1	2/2004	Haluck	6,964,662 B2	11/2005	Kidooka
6,689,131 B2	2/2004	McClurken	6,966,907 B2	11/2005	Goble
6,692,445 B2	2/2004	Roberts et al.	6,972,017 B2	12/2005	Smith et al.
6,693,246 B1	2/2004	Rudolph et al.	6,974,452 B1	12/2005	Gille et al.
6,695,840 B2	2/2004	Schulze	6,976,992 B2	12/2005	Sachatello et al.
6,702,810 B2	3/2004	McClurken et al.	6,977,495 B2	12/2005	Donofrio
6,709,445 B2	3/2004	Boebel et al.	6,979,786 B2	12/2005	Aukland et al.
6,723,092 B2	4/2004	Brown et al.	6,981,628 B2	1/2006	Wales
6,726,068 B2	4/2004	Miller	6,987,244 B2	1/2006	Bauer
6,726,686 B2	4/2004	Buysse et al.	6,989,010 B2	1/2006	Francischelli et al.
6,726,694 B2	4/2004	Blatter et al.	6,989,017 B2	1/2006	Howell et al.
6,733,498 B2	5/2004	Paton et al.	6,994,707 B2	2/2006	Ellman et al.
6,733,501 B2	5/2004	Levine	6,994,709 B2	2/2006	Iida
6,736,813 B2	5/2004	Yamauchi et al.	6,997,931 B2	2/2006	Sauer et al.
6,743,229 B2	6/2004	Buysse et al.	7,001,381 B2	2/2006	Harano et al.
6,743,230 B2	6/2004	Lutze et al.	7,001,408 B2	2/2006	Knodel et al.
6,743,239 B1	6/2004	Kuehn et al.	7,011,657 B2	3/2006	Truckai et al.
6,743,240 B2	6/2004	Smith et al.	7,025,763 B2	4/2006	Karasawa et al.
6,755,338 B2	6/2004	Hahnen et al.	7,033,354 B2	4/2006	Keppel
6,755,824 B2	6/2004	Jain et al.	7,033,356 B2	4/2006	Latterell et al.
6,755,843 B2	6/2004	Chung et al.	7,041,102 B2	5/2006	Truckai et al.
6,756,553 B1	6/2004	Yamaguchi et al.	7,044,948 B2	5/2006	Keppel
6,757,977 B2	7/2004	Dambal et al.	7,052,489 B2	5/2006	Griego et al.
6,758,846 B2	7/2004	Goble et al.	7,052,496 B2	5/2006	Yamauchi
D493,888 S	8/2004	Reschke	7,063,699 B2	6/2006	Hess et al.
6,770,072 B1	8/2004	Truckai et al.	7,063,715 B2	6/2006	Onuki et al.
6,773,409 B2	8/2004	Truckai et al.	D525,361 S	7/2006	Hushka
6,773,432 B1	8/2004	Clayman et al.	7,070,597 B2	7/2006	Truckai et al.
6,773,434 B2	8/2004	Ciarrocca	7,083,480 B2	8/2006	Silber
6,773,435 B2	8/2004	Schulze et al.	7,083,618 B2	8/2006	Couture et al.
6,773,441 B1	8/2004	Laufer et al.	7,083,619 B2	8/2006	Truckai et al.
6,775,575 B2	8/2004	Bommannan et al.	7,083,620 B2	8/2006	Jahns et al.
6,776,780 B2	8/2004	Mulier et al.	7,087,051 B2	8/2006	Bourne et al.
6,780,181 B2	8/2004	Kroll et al.	7,087,054 B2	8/2006	Truckai et al.
6,784,405 B2	8/2004	Flugstad et al.	7,090,673 B2	8/2006	Dycus et al.
6,786,905 B2	9/2004	Swanson et al.	7,090,689 B2	8/2006	Nagase et al.
6,790,217 B2	9/2004	Schulze et al.	7,101,371 B2	9/2006	Dycus et al.
6,796,981 B2	9/2004	Wham et al.	7,101,372 B2	9/2006	Dycus et al.
D496,997 S	10/2004	Dycus et al.	7,101,373 B2	9/2006	Dycus et al.
6,800,825 B1	10/2004	Sasaki et al.	7,103,947 B2	9/2006	Sartor et al.
6,802,843 B2	10/2004	Truckai et al.	7,107,124 B2	9/2006	Green
6,808,525 B2	10/2004	Latterell et al.	7,108,694 B2	9/2006	Miura et al.
D499,181 S	11/2004	Dycus et al.	7,112,199 B2	9/2006	Cosmescu
6,818,000 B2	11/2004	Muller et al.	7,112,201 B2	9/2006	Truckai et al.
6,818,007 B1	11/2004	Dampney et al.	D531,311 S	10/2006	Guerra et al.
6,821,273 B2	11/2004	Mollenauer	7,115,123 B2	10/2006	Knowlton et al.
6,821,285 B2	11/2004	Laufer et al.	7,115,139 B2	10/2006	McClurken et al.
6,824,547 B2	11/2004	Wilson, Jr. et al.	7,118,570 B2	10/2006	Tetzlaff et al.
6,830,174 B2	12/2004	Hillstead et al.	7,118,587 B2	10/2006	Dycus et al.
6,835,200 B2	12/2004	Laufer et al.	7,131,860 B2	11/2006	Sartor et al.
6,843,789 B2	1/2005	Goble	7,131,970 B2	11/2006	Moses et al.
6,857,357 B2	2/2005	Fujii	7,131,971 B2	11/2006	Dycus et al.
6,858,028 B2	2/2005	Mulier et al.	7,135,018 B2	11/2006	Ryan et al.
D502,994 S	3/2005	Blake, III	7,135,020 B2	11/2006	Lawes et al.
6,860,880 B2	3/2005	Treat et al.	7,137,980 B2	11/2006	Buysse et al.
6,878,147 B2	4/2005	Prakash et al.	D533,274 S	12/2006	Visconti et al.
6,887,240 B1	5/2005	Lands et al.	D533,942 S	12/2006	Kerr et al.
6,889,116 B2	5/2005	Jinno	7,145,757 B2	12/2006	Shea et al.
6,905,497 B2	6/2005	Truckai et al.	7,147,632 B2	12/2006	Prakash et al.
6,908,463 B2	6/2005	Treat et al.	7,147,638 B2	12/2006	Chapman et al.
6,914,201 B2	7/2005	Van Vooren et al.	7,150,097 B2	12/2006	Sremoich et al.
6,926,716 B2	8/2005	Baker et al.	7,150,749 B2	12/2006	Dycus et al.
6,929,644 B2	8/2005	Truckai et al.	7,153,314 B2	12/2006	Laufer et al.
6,932,810 B2	8/2005	Ryan	D535,027 S	1/2007	James et al.
6,932,816 B2	8/2005	Phan	7,156,842 B2	1/2007	Sartor et al.
6,934,134 B2	8/2005	Mori et al.	7,156,846 B2	1/2007	Dycus et al.
6,936,061 B2	8/2005	Sasaki	7,160,298 B2	1/2007	Lawes et al.
D509,297 S	9/2005	Wells	7,160,299 B2	1/2007	Baily
6,942,662 B2	9/2005	Goble et al.	7,166,106 B2	1/2007	Bartel et al.
6,943,311 B2	9/2005	Miyako	7,169,145 B2	1/2007	Isaacson et al.
6,951,559 B1	10/2005	Greep	7,169,146 B2	1/2007	Truckai et al.
6,953,430 B2	10/2005	Kidooka	7,179,255 B2	2/2007	Lettice et al.
6,953,461 B2	10/2005	McClurken et al.	7,179,258 B2	2/2007	Buysse et al.
6,958,070 B2	10/2005	Witt et al.	7,184,820 B2	2/2007	Jersey-Willuhn et al.
			D538,932 S	3/2007	Malik
			7,189,233 B2	3/2007	Truckai et al.
			7,195,631 B2	3/2007	Dumbauld
			D541,418 S	4/2007	Schechter et al.

(56)

## References Cited

## U.S. PATENT DOCUMENTS

7,204,832 B2	4/2007	Altshuler et al.	7,553,312 B2	6/2009	Tetzlaff et al.
7,204,835 B2	4/2007	Latterell et al.	7,553,686 B2	6/2009	George et al.
7,207,990 B2	4/2007	Lands et al.	7,569,626 B2	8/2009	Truckai
7,208,005 B2	4/2007	Frecker et al.	7,582,087 B2	9/2009	Tetzlaff et al.
D541,611 S	5/2007	Aglassinger	7,588,565 B2	9/2009	Marchitto et al.
D541,938 S	5/2007	Kerr et al.	7,594,313 B2	9/2009	Prakash et al.
7,211,084 B2	5/2007	Goble et al.	7,594,916 B2	9/2009	Weinberg
7,223,264 B2	5/2007	Daniel et al.	7,597,693 B2	10/2009	Garrison
7,223,265 B2	5/2007	Keppel	7,621,910 B2	11/2009	Sugi
D545,432 S	6/2007	Watanabe	7,624,186 B2	11/2009	Tanida
7,232,440 B2	6/2007	Dumbauld et al.	7,625,370 B2	12/2009	Hart et al.
D547,154 S	7/2007	Lee	7,628,791 B2	12/2009	Garrison et al.
7,238,184 B2	7/2007	Megerman et al.	7,628,792 B2	12/2009	Guerra
7,241,288 B2	7/2007	Braun	7,637,409 B2	12/2009	Marczyk
7,241,296 B2	7/2007	Buyse et al.	7,641,653 B2	1/2010	Dalla Betta et al.
7,244,257 B2	7/2007	Podhajsky et al.	7,651,493 B2	1/2010	Arts et al.
7,246,734 B2	7/2007	Shelton, IV	7,651,494 B2	1/2010	McClurken et al.
7,248,944 B2	7/2007	Green	7,655,004 B2	2/2010	Long
7,252,667 B2	8/2007	Moses et al.	7,655,007 B2	2/2010	Baily
7,254,433 B2	8/2007	Diab et al.	7,668,597 B2	2/2010	Engmark et al.
7,255,697 B2	8/2007	Dycus et al.	7,678,111 B2	3/2010	Mulier et al.
7,258,688 B1	8/2007	Shah et al.	7,686,804 B2	3/2010	Johnson et al.
7,267,677 B2	9/2007	Johnson et al.	7,686,827 B2	3/2010	Hushka
7,270,660 B2	9/2007	Ryan	7,708,735 B2	5/2010	Chapman et al.
7,270,664 B2	9/2007	Johnson et al.	7,717,115 B2	5/2010	Barrett et al.
7,276,068 B2	10/2007	Johnson et al.	7,717,904 B2	5/2010	Suzuki et al.
7,288,103 B2	10/2007	Suzuki	7,717,914 B2	5/2010	Kimura
7,291,161 B2	11/2007	Hooven	7,717,915 B2	5/2010	Miyazawa
7,300,435 B2	11/2007	Wham et al.	7,722,607 B2	5/2010	Dumbauld et al.
7,303,557 B2	12/2007	Wham et al.	D617,900 S	6/2010	Kingsley et al.
7,311,709 B2	12/2007	Truckai et al.	D617,901 S	6/2010	Unger et al.
7,314,471 B2	1/2008	Holman	D617,902 S	6/2010	Twomey et al.
7,318,823 B2	1/2008	Sharps et al.	D617,903 S	6/2010	Unger et al.
7,326,202 B2	2/2008	McGaffigan	D618,798 S	6/2010	Olson et al.
7,329,256 B2	2/2008	Johnson et al.	7,727,231 B2	6/2010	Swanson
7,329,257 B2	2/2008	Kanehira et al.	7,731,717 B2	6/2010	Odom et al.
D564,662 S	3/2008	Moses et al.	7,736,374 B2	6/2010	Vaughan et al.
7,338,526 B2	3/2008	Steinberg	7,744,615 B2	6/2010	Couture
7,342,754 B2	3/2008	Fitzgerald et al.	7,749,217 B2	7/2010	Podhajsky
7,344,268 B2	3/2008	Jigamian	7,753,908 B2	7/2010	Swanson
7,347,864 B2	3/2008	Vargas	7,753,909 B2	7/2010	Chapman et al.
D567,943 S	4/2008	Moses et al.	D621,503 S	8/2010	Otten et al.
7,354,440 B2	4/2008	Truckal et al.	7,766,910 B2	8/2010	Hixson et al.
7,361,172 B2	4/2008	Cimino	7,771,425 B2	8/2010	Dycus et al.
7,367,976 B2	5/2008	Lawes et al.	7,776,036 B2	8/2010	Schechter et al.
7,377,920 B2	5/2008	Buyse et al.	7,776,037 B2	8/2010	Odom
7,384,420 B2	6/2008	Dycus et al.	7,780,662 B2	8/2010	Bahney
7,384,421 B2	6/2008	Hushka	7,789,878 B2	9/2010	Dumbauld et al.
7,396,265 B2	7/2008	Darley et al.	7,799,026 B2	9/2010	Schechter et al.
7,396,336 B2	7/2008	Orszulak et al.	7,799,028 B2	9/2010	Schechter et al.
7,396,356 B2	7/2008	Mollenauer	7,806,892 B2	10/2010	Makin et al.
D575,395 S	8/2008	Hushka	7,811,283 B2	10/2010	Moses et al.
D575,401 S	8/2008	Hixson et al.	7,819,872 B2	10/2010	Johnson et al.
7,422,592 B2	9/2008	Morley et al.	D627,462 S	11/2010	Kingsley
7,425,835 B2	9/2008	Eisele	D628,289 S	11/2010	Romero
7,431,721 B2	10/2008	Paton et al.	D628,290 S	11/2010	Romero
7,435,249 B2	10/2008	Buyse et al.	7,828,798 B2	11/2010	Buyse et al.
7,438,714 B2	10/2008	Phan	7,832,408 B2	11/2010	Shelton, IV et al.
7,442,193 B2	10/2008	Shields et al.	7,837,685 B2	11/2010	Weinberg et al.
7,442,194 B2	10/2008	Dumbauld et al.	7,839,674 B2	11/2010	Lowrey et al.
7,445,621 B2	11/2008	Dumbauld et al.	7,842,033 B2	11/2010	Isaacson et al.
D582,038 S	12/2008	Swoyer et al.	7,846,158 B2	12/2010	Podhajsky
7,458,972 B2	12/2008	Keppel	7,846,161 B2	12/2010	Dumbauld et al.
7,473,253 B2	1/2009	Dycus et al.	7,857,812 B2	12/2010	Dycus et al.
7,481,810 B2	1/2009	Dumbauld et al.	D630,324 S	1/2011	Reschke
7,487,780 B2	2/2009	Hooven	7,877,852 B2	2/2011	Unger et al.
7,491,201 B2	2/2009	Shields et al.	7,877,853 B2	2/2011	Unger et al.
7,491,202 B2	2/2009	Odom et al.	7,879,035 B2	2/2011	Garrison et al.
7,500,975 B2	3/2009	Cunningham et al.	7,887,535 B2	2/2011	Lands et al.
7,503,474 B2	3/2009	Hillstead et al.	7,887,536 B2	2/2011	Johnson et al.
7,510,556 B2	3/2009	Nguyen et al.	7,896,878 B2	3/2011	Johnson et al.
7,513,898 B2	4/2009	Johnson et al.	7,898,288 B2	3/2011	Wong
7,517,351 B2	4/2009	Culp et al.	7,900,805 B2	3/2011	Shelton, IV et al.
7,540,872 B2	6/2009	Schechter et al.	7,901,400 B2	3/2011	Wham et al.
7,549,995 B2	6/2009	Schultz	7,905,380 B2	3/2011	Shelton, IV et al.
			7,905,881 B2	3/2011	Masuda et al.
			7,909,820 B2	3/2011	Lipson et al.
			7,909,823 B2	3/2011	Moses et al.
			7,909,824 B2	3/2011	Masuda et al.



(56)

## References Cited

## U.S. PATENT DOCUMENTS

7,918,848 B2	4/2011	Lau et al.	8,257,387 B2	9/2012	Cunningham
7,922,718 B2	4/2011	Moses et al.	8,282,634 B2	10/2012	Cunningham et al.
7,922,742 B2	4/2011	Hillstead et al.	D670,808 S	11/2012	Moua et al.
7,922,953 B2	4/2011	Guerra	8,303,582 B2	11/2012	Cunningham
7,931,649 B2	4/2011	Couture et al.	8,317,787 B2	11/2012	Hanna
7,935,052 B2	5/2011	Dumbauld	8,328,803 B2	12/2012	Regadas
7,945,332 B2	5/2011	Schechter	8,333,765 B2	12/2012	Johnson et al.
7,947,041 B2	5/2011	Tetzlaff et al.	8,382,792 B2	2/2013	Chojin
7,949,407 B2	5/2011	Kaplan et al.	D680,220 S	4/2013	Rachlin
7,951,149 B2	5/2011	Carlton	8,454,602 B2	6/2013	Kerr et al.
7,951,150 B2	5/2011	Johnson et al.	8,469,956 B2	6/2013	McKenna et al.
7,955,326 B2	6/2011	Paul et al.	8,469,957 B2	6/2013	Roy
7,955,327 B2	6/2011	Sartor et al.	8,486,107 B2	7/2013	Hinton
7,955,331 B2	6/2011	Truckai et al.	8,512,371 B2	8/2013	Kerr et al.
7,955,332 B2	6/2011	Arts et al.	8,523,898 B2	9/2013	Bucciaglia et al.
7,967,839 B2	6/2011	Flock et al.	8,529,566 B2	9/2013	Kappus et al.
7,972,328 B2	7/2011	Wham et al.	8,535,312 B2	9/2013	Horner
7,972,331 B2	7/2011	Hafner	8,568,408 B2	10/2013	Townsend et al.
7,976,544 B2	7/2011	McClurken et al.	8,568,412 B2	10/2013	Brandt et al.
7,981,113 B2	7/2011	Truckai et al.	8,591,510 B2	11/2013	Allen, IV et al.
7,988,507 B2	8/2011	Darley et al.	8,623,276 B2	1/2014	Schmaltz et al.
7,998,095 B2	8/2011	McAuley	8,628,557 B2	1/2014	Collings et al.
8,012,150 B2	9/2011	Wham et al.	8,632,539 B2	1/2014	Twomey et al.
8,016,827 B2	9/2011	Chojin	8,632,564 B2	1/2014	Cunningham
8,034,049 B2	10/2011	Odom et al.	8,636,761 B2	1/2014	Cunningham et al.
D649,249 S	11/2011	Guerra	8,668,689 B2	3/2014	Dumbauld et al.
D649,643 S	11/2011	Allen, IV et al.	8,679,098 B2	3/2014	Hart
8,048,074 B2	11/2011	Masuda	8,679,114 B2	3/2014	Chapman et al.
8,070,746 B2	12/2011	Orton et al.	8,679,115 B2	3/2014	Reschke
8,070,748 B2	12/2011	Hixson et al.	8,679,140 B2	3/2014	Butcher
8,075,580 B2	12/2011	Makower	8,685,009 B2	4/2014	Chernov et al.
8,089,417 B2	1/2012	Popovic et al.	8,685,056 B2	4/2014	Evans et al.
8,092,451 B2	1/2012	Schechter et al.	8,696,667 B2	4/2014	Guerra et al.
8,104,956 B2	1/2012	Blaha	8,702,737 B2	4/2014	Chojin et al.
8,112,871 B2	2/2012	Brandt et al.	8,702,749 B2	4/2014	Twomey
8,114,122 B2	2/2012	Nau, Jr.	8,745,840 B2	6/2014	Hempstead et al.
8,123,743 B2	2/2012	Arts et al.	8,747,413 B2	6/2014	Dycus
8,128,624 B2	3/2012	Couture et al.	8,747,434 B2	6/2014	Larson et al.
8,128,625 B2	3/2012	Odom	8,752,264 B2	6/2014	Ackley et al.
8,133,224 B2	3/2012	Geiselhart	8,756,785 B2	6/2014	Allen, IV et al.
8,133,254 B2	3/2012	Dumbauld et al.	8,764,748 B2	7/2014	Chojin
8,142,425 B2	3/2012	Eggers	8,784,417 B2	7/2014	Hanna
8,142,473 B2	3/2012	Cunningham	8,795,274 B2	8/2014	Hanna
8,147,485 B2	4/2012	Wham et al.	8,845,636 B2	9/2014	Allen, IV et al.
8,147,489 B2	4/2012	Moses et al.	8,852,185 B2	10/2014	Twomey
8,157,145 B2	4/2012	Shelton, IV et al.	8,864,753 B2	10/2014	Nau, Jr. et al.
8,161,977 B2	4/2012	Shelton, IV et al.	8,864,795 B2	10/2014	Kerr et al.
8,162,940 B2	4/2012	Johnson et al.	8,887,373 B2	11/2014	Brandt et al.
8,162,965 B2	4/2012	Reschke et al.	8,888,771 B2	11/2014	Twomey
8,162,973 B2	4/2012	Cunningham	8,900,232 B2	12/2014	Ourada
8,177,794 B2	5/2012	Cabrera et al.	8,920,461 B2	12/2014	Unger et al.
8,181,649 B2	5/2012	Brunner	8,939,972 B2	1/2015	Twomey
8,182,476 B2	5/2012	Julian et al.	8,961,513 B2	2/2015	Allen, IV et al.
8,187,273 B2	5/2012	Kerr et al.	8,961,514 B2	2/2015	Garrison
D661,394 S	6/2012	Romero et al.	8,961,515 B2	2/2015	Twomey et al.
8,192,433 B2	6/2012	Johnson et al.	8,968,283 B2	3/2015	Kharin
8,192,444 B2	6/2012	Dycus	8,968,298 B2	3/2015	Twomey
8,197,479 B2	6/2012	Olson et al.	8,968,305 B2	3/2015	Dumbauld et al.
8,197,633 B2	6/2012	Guerra	8,968,306 B2	3/2015	Unger
8,207,651 B2	6/2012	Gilbert	8,968,307 B2	3/2015	Evans et al.
8,211,105 B2	7/2012	Buyse et al.	8,968,308 B2	3/2015	Horner et al.
8,215,182 B2	7/2012	Artale et al.	8,968,309 B2	3/2015	Roy et al.
8,216,223 B2	7/2012	Wham et al.	8,968,310 B2	3/2015	Twomey et al.
8,221,416 B2	7/2012	Townsend	8,968,311 B2	3/2015	Allen, IV et al.
8,226,650 B2	7/2012	Kerr	8,968,314 B2	3/2015	Allen, IV
8,235,992 B2	8/2012	Guerra et al.	8,968,317 B2	3/2015	Evans et al.
8,235,993 B2	8/2012	Hushka et al.	8,968,360 B2	3/2015	Garrison et al.
8,236,025 B2	8/2012	Hushka et al.	9,011,435 B2	4/2015	Brandt et al.
8,241,282 B2	8/2012	Unger et al.	9,023,035 B2	5/2015	Allen, IV et al.
8,241,283 B2	8/2012	Guerra et al.	9,024,237 B2	5/2015	Bonn
8,241,284 B2	8/2012	Dycus et al.	9,028,492 B2	5/2015	Kerr et al.
8,246,618 B2	8/2012	Bucciaglia et al.	9,033,981 B2	5/2015	Olson et al.
8,251,994 B2	8/2012	McKenna et al.	9,034,009 B2	5/2015	Twomey et al.
8,251,996 B2	8/2012	Hushka et al.	9,039,691 B2	5/2015	Moua et al.
8,257,352 B2	9/2012	Lawes et al.	9,039,704 B2	5/2015	Joseph
			9,039,732 B2	5/2015	Sims et al.
			9,060,780 B2	6/2015	Twomey et al.
			9,060,798 B2	6/2015	Harper et al.
			9,113,882 B2	8/2015	Twomey et al.

(56)

## References Cited

## U.S. PATENT DOCUMENTS

9,113,899	B2	8/2015	Garrison et al.	2005/0004569	A1	1/2005	Witt et al.
9,113,901	B2	8/2015	Allen, IV et al.	2005/0004570	A1	1/2005	Chapman et al.
9,113,909	B2	8/2015	Twomey et al.	2005/0021025	A1	1/2005	Buysse et al.
9,113,933	B2	8/2015	Chernova et al.	2005/0021026	A1	1/2005	Baily
9,113,934	B2	8/2015	Chernov et al.	2005/0021027	A1	1/2005	Shields et al.
9,113,938	B2	8/2015	Kerr	2005/0033278	A1	2/2005	McClurken et al.
9,192,427	B2	11/2015	Johnson et al.	2005/0059858	A1	3/2005	Frith et al.
9,375,254	B2	6/2016	Heard	2005/0059934	A1	3/2005	Wenchell et al.
9,603,652	B2	3/2017	Carlton et al.	2005/0090817	A1	4/2005	Phan
10,265,121	B2	4/2019	Dycus et al.	2005/0096645	A1	5/2005	Wellman et al.
2001/0037109	A1	11/2001	Yamauchi et al.	2005/0101951	A1	5/2005	Wham et al.
2002/0013583	A1	1/2002	Camran et al.	2005/0101952	A1	5/2005	Lands et al.
2002/0029036	A1	3/2002	Goble et al.	2005/0107784	A1	5/2005	Moses et al.
2002/0049442	A1	4/2002	Roberts et al.	2005/0107785	A1	5/2005	Dycus et al.
2002/0099372	A1	7/2002	Schulze et al.	2005/0113818	A1	5/2005	Sartor et al.
2002/0099373	A1	7/2002	Schulze et al.	2005/0113819	A1	5/2005	Wham et al.
2002/0107517	A1	8/2002	Witt et al.	2005/0113826	A1	5/2005	Johnson et al.
2002/0111624	A1	8/2002	Witt et al.	2005/0113827	A1	5/2005	Dumbauld et al.
2002/0165469	A1	11/2002	Murakami	2005/0113828	A1	5/2005	Shields et al.
2002/0188294	A1	12/2002	Couture et al.	2005/0119655	A1	6/2005	Moses et al.
2003/0014052	A1	1/2003	Buysse et al.	2005/0149017	A1	7/2005	Dycus
2003/0014053	A1	1/2003	Nguyen et al.	2005/0149151	A1	7/2005	Orszulak et al.
2003/0018331	A1	1/2003	Dycus et al.	2005/0154387	A1	7/2005	Moses et al.
2003/0018332	A1	1/2003	Schmaltz et al.	2005/0187547	A1	8/2005	Sugi
2003/0069570	A1	4/2003	Witzel et al.	2005/0197659	A1	9/2005	Bahney
2003/0069571	A1	4/2003	Treat et al.	2005/0203504	A1	9/2005	Wham et al.
2003/0078578	A1	4/2003	Truckai et al.	2005/0222560	A1	10/2005	Kimura et al.
2003/0109875	A1	6/2003	Tetzlaff et al.	2005/0240179	A1	10/2005	Buysse et al.
2003/0114851	A1	6/2003	Truckai et al.	2005/0254081	A1	11/2005	Ryu et al.
2003/0130653	A1	7/2003	Sixto et al.	2005/0261588	A1	11/2005	Makin et al.
2003/0139741	A1	7/2003	Goble et al.	2005/0283148	A1	12/2005	Janssen et al.
2003/0139742	A1	7/2003	Wampler et al.	2006/0052777	A1	3/2006	Dumbauld
2003/0158548	A1	8/2003	Phan et al.	2006/0052778	A1	3/2006	Chapman et al.
2003/0158549	A1	8/2003	Swanson	2006/0052779	A1	3/2006	Hammill
2003/0171747	A1	9/2003	Kanehira et al.	2006/0064085	A1	3/2006	Schechter et al.
2003/0181898	A1	9/2003	Bowers	2006/0064086	A1	3/2006	Odom
2003/0181910	A1	9/2003	Dycus et al.	2006/0079888	A1	4/2006	Mulier et al.
2003/0191396	A1	10/2003	Sanghvi et al.	2006/0079890	A1	4/2006	Guerra
2003/0199869	A1	10/2003	Johnson et al.	2006/0079891	A1	4/2006	Arts et al.
2003/0216732	A1	11/2003	Truckai et al.	2006/0079933	A1	4/2006	Hushka et al.
2003/0220637	A1	11/2003	Truckai et al.	2006/0084973	A1	4/2006	Hushka
2003/0229344	A1	12/2003	Dycus et al.	2006/0089670	A1	4/2006	Hushka
2003/0236325	A1	12/2003	Bonora	2006/0111711	A1	5/2006	Goble
2003/0236518	A1	12/2003	Marchitto et al.	2006/0116675	A1	6/2006	McClurken et al.
2004/0030330	A1	2/2004	Brassell et al.	2006/0129146	A1	6/2006	Dycus et al.
2004/0030332	A1	2/2004	Knowlton et al.	2006/0161150	A1	7/2006	Keppel
2004/0049185	A1	3/2004	Latterell et al.	2006/0167450	A1	7/2006	Johnson et al.
2004/0064151	A1	4/2004	Mollenauer	2006/0167452	A1	7/2006	Moses et al.
2004/0073238	A1	4/2004	Makower	2006/0173452	A1	8/2006	Buysse et al.
2004/0073256	A1	4/2004	Marchitto et al.	2006/0189980	A1	8/2006	Johnson et al.
2004/0082952	A1	4/2004	Dycus et al.	2006/0189981	A1	8/2006	Dycus et al.
2004/0087943	A1	5/2004	Dycus et al.	2006/0190035	A1	8/2006	Hushka et al.
2004/0115296	A1	6/2004	Duffin	2006/0217709	A1	9/2006	Couture et al.
2004/0116979	A1	6/2004	Truckai et al.	2006/0224053	A1	10/2006	Black et al.
2004/0122423	A1	6/2004	Dycus et al.	2006/0224158	A1	10/2006	Odom et al.
2004/0143263	A1	7/2004	Schechter et al.	2006/0229666	A1	10/2006	Suzuki et al.
2004/0147925	A1	7/2004	Buysse et al.	2006/0253126	A1	11/2006	Bjerken et al.
2004/0148035	A1	7/2004	Barrett et al.	2006/0259036	A1	11/2006	Tetzlaff et al.
2004/0162557	A1	8/2004	Tetzlaff et al.	2006/0264922	A1	11/2006	Sartor et al.
2004/0176779	A1	9/2004	Casutt et al.	2006/0264931	A1	11/2006	Chapman et al.
2004/0199181	A1	10/2004	Knodel et al.	2006/0271030	A1	11/2006	Francis et al.
2004/0210282	A1	10/2004	Flock et al.	2006/0271038	A1	11/2006	Johnson et al.
2004/0224590	A1	11/2004	Rawa et al.	2006/0283093	A1	12/2006	Petrovic et al.
2004/0225288	A1	11/2004	Buysse et al.	2006/0287641	A1	12/2006	Perlin
2004/0230189	A1	11/2004	Keppel	2007/0016182	A1	1/2007	Lipson et al.
2004/0236325	A1	11/2004	Tetzlaff et al.	2007/0016187	A1	1/2007	Weinberg et al.
2004/0236326	A1	11/2004	Schulze et al.	2007/0027447	A1	2/2007	Theroux et al.
2004/0243125	A1	12/2004	Dycus et al.	2007/0043352	A1	2/2007	Garrison et al.
2004/0249371	A1	12/2004	Dycus et al.	2007/0043353	A1	2/2007	Dycus et al.
2004/0249374	A1	12/2004	Tetzlaff et al.	2007/0055231	A1	3/2007	Dycus et al.
2004/0250419	A1	12/2004	Sremcich et al.	2007/0060919	A1	3/2007	Isaacson et al.
2004/0254573	A1	12/2004	Dycus et al.	2007/0062017	A1	3/2007	Dycus et al.
2004/0260281	A1	12/2004	Baxter et al.	2007/0074807	A1	4/2007	Guerra
2005/0004564	A1	1/2005	Wham et al.	2007/0078456	A1	4/2007	Dumbauld et al.
2005/0004568	A1	1/2005	Lawes et al.	2007/0078458	A1	4/2007	Dumbauld et al.
				2007/0078459	A1	4/2007	Johnson et al.
				2007/0088356	A1	4/2007	Moses et al.
				2007/0106295	A1	5/2007	Garrison et al.
				2007/0106297	A1	5/2007	Dumbauld et al.

(56)

## References Cited

## U.S. PATENT DOCUMENTS

2007/0118111 A1	5/2007	Weinberg	2009/0088745 A1	4/2009	Hushka et al.
2007/0118115 A1	5/2007	Artale et al.	2009/0088746 A1	4/2009	Hushka et al.
2007/0142833 A1	6/2007	Dycus et al.	2009/0088747 A1	4/2009	Hushka et al.
2007/0142834 A1	6/2007	Dumbauld	2009/0088748 A1	4/2009	Guerra et al.
2007/0156139 A1	7/2007	Schechter et al.	2009/0088749 A1	4/2009	Hushka et al.
2007/0156140 A1	7/2007	Baily	2009/0088750 A1	4/2009	Hushka et al.
2007/0173811 A1	7/2007	Couture et al.	2009/0105750 A1	4/2009	Price et al.
2007/0173813 A1	7/2007	Odom	2009/0112206 A1	4/2009	Dumbauld et al.
2007/0173814 A1	7/2007	Hixson et al.	2009/0112229 A1	4/2009	Omori et al.
2007/0179499 A1	8/2007	Garrison	2009/0131934 A1	5/2009	Odom et al.
2007/0198011 A1	8/2007	Sugita	2009/0138003 A1	5/2009	Deville et al.
2007/0203485 A1	8/2007	Keppel	2009/0138006 A1	5/2009	Bales et al.
2007/0213706 A1	9/2007	Dumbauld et al.	2009/0149853 A1	6/2009	Shields et al.
2007/0213707 A1	9/2007	Dumbauld et al.	2009/0149854 A1	6/2009	Cunningham et al.
2007/0213708 A1	9/2007	Dumbauld et al.	2009/0157071 A1	6/2009	Wham et al.
2007/0213712 A1	9/2007	Buyse et al.	2009/0171350 A1	7/2009	Dycus et al.
2007/0225695 A1	9/2007	Mayer et al.	2009/0171353 A1	7/2009	Johnson et al.
2007/0255279 A1	11/2007	Buyse et al.	2009/0171354 A1	7/2009	Deville et al.
2007/0260235 A1	11/2007	Podhajsky	2009/0177094 A1	7/2009	Brown et al.
2007/0260238 A1	11/2007	Guerra	2009/0182327 A1	7/2009	Unger
2007/0260241 A1	11/2007	Dalla Betta et al.	2009/0187188 A1	7/2009	Guerra et al.
2007/0260242 A1	11/2007	Dycus et al.	2009/0198233 A1	8/2009	Chojin
2007/0265616 A1	11/2007	Couture et al.	2009/0204114 A1	8/2009	Odom
2007/0265620 A1	11/2007	Kraas et al.	2009/0204137 A1	8/2009	Maxwell
2008/0004616 A1	1/2008	Patrick	2009/0206126 A1	8/2009	Huitema et al.
2008/0009860 A1	1/2008	Odom	2009/0209957 A1	8/2009	Schmaltz et al.
2008/0015563 A1	1/2008	Hoey et al.	2009/0209960 A1	8/2009	Chojin
2008/0015575 A1	1/2008	Odom et al.	2009/0234354 A1	9/2009	Johnson et al.
2008/0021450 A1	1/2008	Couture	2009/0248007 A1	10/2009	Falkenstein et al.
2008/0033428 A1	2/2008	Artale et al.	2009/0248013 A1	10/2009	Falkenstein et al.
2008/0039835 A1	2/2008	Johnson et al.	2009/0248019 A1	10/2009	Falkenstein et al.
2008/0039836 A1	2/2008	Odom et al.	2009/0248020 A1	10/2009	Falkenstein et al.
2008/0045947 A1	2/2008	Johnson et al.	2009/0248021 A1	10/2009	McKenna
2008/0046122 A1	2/2008	Manzo et al.	2009/0248022 A1	10/2009	Falkenstein et al.
2008/0058802 A1	3/2008	Couture et al.	2009/0248050 A1	10/2009	Hirai
2008/0082100 A1	4/2008	Orton et al.	2009/0254080 A1	10/2009	Honda
2008/0091189 A1	4/2008	Carlton	2009/0254081 A1	10/2009	Allison et al.
2008/0125797 A1	5/2008	Kelleher	2009/0261804 A1	10/2009	McKenna et al.
2008/0171938 A1	7/2008	Masuda et al.	2009/0270771 A1	10/2009	Takahashi
2008/0172051 A1	7/2008	Masuda et al.	2009/0275865 A1	11/2009	Zhao et al.
2008/0195093 A1	8/2008	Couture et al.	2009/0292282 A9	11/2009	Dycus
2008/0215050 A1	9/2008	Bakos	2009/0299364 A1	12/2009	Batchelor et al.
2008/0215051 A1	9/2008	Buyse et al.	2009/0312273 A1	12/2009	De La Torre
2008/0234672 A1	9/2008	Bastian	2009/0318912 A1	12/2009	Mayer et al.
2008/0234701 A1	9/2008	Morales et al.	2010/0016857 A1	1/2010	McKenna et al.
2008/0243106 A1	10/2008	Coe et al.	2010/0023009 A1	1/2010	Moses et al.
2008/0243120 A1	10/2008	Lawes et al.	2010/0036375 A1	2/2010	Regadas
2008/0243158 A1	10/2008	Morgan	2010/0042143 A1	2/2010	Cunningham
2008/0249523 A1	10/2008	McPherson et al.	2010/0049187 A1	2/2010	Carlton et al.
2008/0249527 A1	10/2008	Couture	2010/0049194 A1	2/2010	Hart et al.
2008/0271360 A1	11/2008	Barfield	2010/0057078 A1	3/2010	Arts et al.
2008/0281311 A1	11/2008	Dunning et al.	2010/0057081 A1	3/2010	Hanna
2008/0312653 A1	12/2008	Arts et al.	2010/0057082 A1	3/2010	Hanna
2008/0319292 A1	12/2008	Say et al.	2010/0057083 A1	3/2010	Hanna
2008/0319442 A1	12/2008	Unger et al.	2010/0057084 A1	3/2010	Hanna
2009/0012520 A1	1/2009	Hixson et al.	2010/0063500 A1	3/2010	Muszala
2009/0012556 A1	1/2009	Boudreaux et al.	2010/0069903 A1	3/2010	Allen, IV et al.
2009/0018535 A1	1/2009	Schechter et al.	2010/0069904 A1	3/2010	Cunningham
2009/0024126 A1	1/2009	Artale et al.	2010/0069953 A1	3/2010	Cunningham et al.
2009/0036881 A1	2/2009	Artale et al.	2010/0076427 A1	3/2010	Heard
2009/0036899 A1	2/2009	Carlton et al.	2010/0076430 A1	3/2010	Romero
2009/0043304 A1	2/2009	Tetzlaff et al.	2010/0076431 A1	3/2010	Allen, IV
2009/0048596 A1	2/2009	Shields et al.	2010/0087816 A1	4/2010	Roy
2009/0054894 A1	2/2009	Yachi	2010/0094271 A1	4/2010	Ward et al.
2009/0062794 A1	3/2009	Buyse et al.	2010/0094287 A1	4/2010	Cunningham et al.
2009/0065565 A1	3/2009	Cao	2010/0094289 A1	4/2010	Taylor et al.
2009/0076506 A1	3/2009	Baker	2010/0100122 A1	4/2010	Hinton
2009/0082766 A1	3/2009	Unger et al.	2010/0130971 A1	5/2010	Baily
2009/0082767 A1	3/2009	Unger et al.	2010/0130977 A1	5/2010	Garrison et al.
2009/0082769 A1	3/2009	Unger et al.	2010/0168741 A1	7/2010	Sanai et al.
2009/0088738 A1	4/2009	Guerra et al.	2010/0179543 A1	7/2010	Johnson et al.
2009/0088739 A1	4/2009	Hushka et al.	2010/0179545 A1	7/2010	Twomey et al.
2009/0088740 A1	4/2009	Guerra et al.	2010/0179546 A1	7/2010	Cunningham
2009/0088741 A1	4/2009	Hushka et al.	2010/0179547 A1	7/2010	Cunningham et al.
2009/0088744 A1	4/2009	Townsend	2010/0198218 A1	8/2010	Manzo
			2010/0198248 A1	8/2010	Vakharia
			2010/0204697 A1	8/2010	Dumbauld et al.
			2010/0217258 A1	8/2010	Floume et al.
			2010/0217264 A1	8/2010	Odom et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

2010/0228249 A1 9/2010 Mohr et al.  
 2010/0228250 A1 9/2010 Brogna  
 2010/0249769 A1 9/2010 Nau, Jr. et al.  
 2010/0274160 A1 10/2010 Yachi et al.  
 2010/0274244 A1 10/2010 Heard  
 2010/0274265 A1 10/2010 Wingardner et al.  
 2010/0280511 A1 11/2010 Rachlin et al.  
 2010/0292691 A1 11/2010 Brogna  
 2010/0305558 A1 12/2010 Kimura et al.  
 2010/0307934 A1 12/2010 Chowaniec et al.  
 2010/0312235 A1 12/2010 Bahney  
 2010/0331742 A1 12/2010 Masuda  
 2010/0331839 A1 12/2010 Schechter et al.  
 2011/0004210 A1 1/2011 Johnson et al.  
 2011/0015632 A1 1/2011 Artale  
 2011/0018164 A1 1/2011 Sartor et al.  
 2011/0034918 A1 2/2011 Reschke  
 2011/0054467 A1 3/2011 Mueller et al.  
 2011/0054468 A1 3/2011 Dycus  
 2011/0054469 A1 3/2011 Kappus et al.  
 2011/0054471 A1 3/2011 Gerhardt et al.  
 2011/0054472 A1 3/2011 Romero  
 2011/0060333 A1 3/2011 Mueller  
 2011/0060335 A1 3/2011 Harper et al.  
 2011/0071523 A1 3/2011 Dickhans  
 2011/0071525 A1 3/2011 Dumbauld et al.  
 2011/0072638 A1 3/2011 Brandt et al.  
 2011/0077637 A1 3/2011 Brannan  
 2011/0077648 A1 3/2011 Lee et al.  
 2011/0077649 A1 3/2011 Kingsley  
 2011/0082457 A1 4/2011 Kerr et al.  
 2011/0087221 A1 4/2011 Siebrecht et al.  
 2011/0098689 A1 4/2011 Nau, Jr. et al.  
 2011/0106079 A1 5/2011 Garrison et al.  
 2011/0178519 A1 7/2011 Couture et al.  
 2011/0184405 A1 7/2011 Mueller  
 2011/0190653 A1 8/2011 Harper et al.  
 2011/0190765 A1 8/2011 Chojin  
 2011/0193608 A1 8/2011 Krapohl  
 2011/0218530 A1 9/2011 Reschke  
 2011/0230880 A1 9/2011 Chojin et al.  
 2011/0238066 A1 9/2011 Olson  
 2011/0238067 A1 9/2011 Moses et al.  
 2011/0251605 A1 10/2011 Hoarau et al.  
 2011/0251606 A1 10/2011 Kerr  
 2011/0251611 A1 10/2011 Horner et al.  
 2011/0257680 A1 10/2011 Reschke et al.  
 2011/0257681 A1 10/2011 Reschke et al.  
 2011/0270245 A1 11/2011 Horner et al.  
 2011/0270250 A1 11/2011 Horner et al.  
 2011/0270251 A1 11/2011 Horner et al.  
 2011/0270252 A1 11/2011 Horner et al.  
 2011/0275901 A1 11/2011 Shelton, IV  
 2011/0276048 A1 11/2011 Kerr et al.  
 2011/0276049 A1 11/2011 Gerhardt  
 2011/0295251 A1 12/2011 Garrison  
 2011/0295313 A1 12/2011 Kerr  
 2011/0301592 A1 12/2011 Kerr et al.  
 2011/0301599 A1 12/2011 Roy et al.  
 2011/0301600 A1 12/2011 Garrison et al.  
 2011/0301601 A1 12/2011 Garrison et al.  
 2011/0301602 A1 12/2011 Roy et al.  
 2011/0301603 A1 12/2011 Kerr et al.  
 2011/0301604 A1 12/2011 Horner et al.  
 2011/0301605 A1 12/2011 Horner  
 2011/0301606 A1 12/2011 Kerr  
 2011/0301637 A1 12/2011 Kerr et al.  
 2011/0319886 A1 12/2011 Chojin et al.  
 2011/0319888 A1 12/2011 Mueller et al.  
 2012/0004658 A1 1/2012 Chojin  
 2012/0010614 A1 1/2012 Couture  
 2012/0022532 A1 1/2012 Garrison  
 2012/0029515 A1 2/2012 Couture  
 2012/0041438 A1 2/2012 Nau, Jr. et al.  
 2012/0046659 A1 2/2012 Mueller

2012/0046660 A1 2/2012 Nau, Jr.  
 2012/0046662 A1 2/2012 Gilbert  
 2012/0059371 A1 3/2012 Anderson et al.  
 2012/0059372 A1 3/2012 Johnson  
 2012/0059374 A1 3/2012 Johnson et al.  
 2012/0059375 A1 3/2012 Couture et al.  
 2012/0059408 A1 3/2012 Mueller  
 2012/0059409 A1 3/2012 Reschke et al.  
 2012/0078250 A1 3/2012 Orton et al.  
 2012/0083785 A1 4/2012 Roy et al.  
 2012/0083786 A1 4/2012 Artale et al.  
 2012/0083827 A1 4/2012 Artale et al.  
 2012/0095456 A1 4/2012 Schechter et al.  
 2012/0095460 A1 4/2012 Rooks et al.  
 2012/0109187 A1 5/2012 Gerhardt, Jr. et al.  
 2012/0118507 A1 5/2012 Brandt et al.  
 2012/0123402 A1 5/2012 Chernov et al.  
 2012/0123404 A1 5/2012 Craig  
 2012/0123410 A1 5/2012 Craig  
 2012/0123413 A1 5/2012 Chernov et al.  
 2012/0130367 A1 5/2012 Garrison  
 2012/0136353 A1 5/2012 Romero  
 2012/0136354 A1 5/2012 Rupp  
 2012/0143185 A1 6/2012 Nau, Jr.  
 2012/0165797 A1 6/2012 Cunningham  
 2012/0165818 A1 6/2012 Odom  
 2012/0172868 A1 7/2012 Twomey et al.  
 2012/0172873 A1 7/2012 Artale et al.  
 2012/0172924 A1 7/2012 Allen, IV  
 2012/0172925 A1 7/2012 Dumbauld et al.  
 2012/0184989 A1 7/2012 Twomey  
 2012/0184990 A1 7/2012 Twomey  
 2012/0202179 A1 8/2012 Fedotov et al.  
 2012/0209263 A1 8/2012 Sharp et al.  
 2012/0215219 A1 8/2012 Roy et al.  
 2012/0215242 A1 8/2012 Reschke et al.  
 2012/0239034 A1 9/2012 Horner et al.  
 2012/0259331 A1 10/2012 Garrison  
 2012/0265241 A1 10/2012 Hart et al.  
 2012/0296205 A1 11/2012 Chernov et al.  
 2012/0296238 A1 11/2012 Chernov et al.  
 2012/0296239 A1 11/2012 Chernov et al.  
 2012/0296323 A1 11/2012 Chernov et al.  
 2012/0296371 A1 11/2012 Kappus et al.  
 2012/0303025 A1 11/2012 Garrison  
 2012/0303026 A1 11/2012 Dycus et al.  
 2012/0323238 A1 12/2012 Tyrrell et al.  
 2012/0330308 A1 12/2012 Joseph  
 2013/0018364 A1 1/2013 Chernov et al.  
 2013/0022495 A1 1/2013 Allen, IV et al.  
 2013/0071282 A1 3/2013 Fry  
 2013/0072927 A1 3/2013 Allen, IV et al.  
 2013/0079760 A1 3/2013 Twomey et al.  
 2013/0079774 A1 3/2013 Whitney et al.  
 2013/0085496 A1 4/2013 Unger et al.  
 2013/0103030 A1 4/2013 Garrison  
 2013/0103031 A1 4/2013 Garrison  
 2013/0138101 A1 5/2013 Kerr  
 2013/0144284 A1 6/2013 Behnke, II et al.  
 2013/0197503 A1 8/2013 Orszulak  
 2013/0253489 A1 9/2013 Nau, Jr. et al.  
 2013/0255063 A1 10/2013 Hart et al.  
 2013/0274736 A1 10/2013 Garrison  
 2013/0289561 A1 10/2013 Waaler et al.  
 2013/0296922 A1 11/2013 Allen, IV et al.  
 2013/0304058 A1 11/2013 Kendrick  
 2013/0304066 A1 11/2013 Kerr et al.  
 2013/0325057 A1 12/2013 Larson et al.  
 2015/0011930 A1\* 1/2015 Yamanishi ..... A61B 18/12  
 2015/0250532 A1 9/2015 Dycus et al.  
 2015/0257819 A1 9/2015 Dycus et al.  
 2017/0042607 A1 2/2017 Dycus et al.

604/23

FOREIGN PATENT DOCUMENTS

CA 2590520 A1 11/2007  
 CN 201299462 Y 9/2009  
 DE 2415263 A1 10/1975

(56)

## References Cited

## FOREIGN PATENT DOCUMENTS

DE	02514501	A1	10/1976	EP	1645238	A1	4/2006
DE	2627679	A1	1/1977	EP	1645240	A2	4/2006
DE	03423356	A1	1/1986	EP	1649821	A1	4/2006
DE	03612646	A1	4/1987	EP	0875209	B1	5/2006
DE	3627221	A1	2/1988	EP	1683496	A2	7/2006
DE	8712328	U1	2/1988	EP	1707143	A1	10/2006
DE	04303882	C2	2/1995	EP	1769765	A1	4/2007
DE	04403252	A1	8/1995	EP	1769766	A1	4/2007
DE	19515914	C1	7/1996	EP	1929970	A1	6/2008
DE	19506363	A1	8/1996	EP	1946715	A1	7/2008
DE	29616210	U1	11/1996	EP	2382936	A1	11/2011
DE	19608716	C1	4/1997	GB	623316	A	5/1949
DE	19751106	A1	5/1998	GB	1490585	A	11/1977
DE	19738457	A1	3/1999	GB	2213416	A	8/1989
DE	19751108	A1	5/1999	GB	2214430	A	9/1989
DE	19946527	C1	7/2001	JP	61501068	A	5/1986
DE	10031773	A1	11/2001	JP	1024051		1/1989
DE	10045375	A1	4/2002	JP	1147150		6/1989
DE	20121161	U1	4/2002	JP	H055106	A	1/1993
DE	202007009165	U1	8/2007	JP	H0540112	A	2/1993
DE	202007009317	U1	8/2007	JP	6121797		5/1994
DE	202007009318	U1	8/2007	JP	6285078	A	10/1994
DE	202007016233	U1	1/2008	JP	6511401	A	12/1994
DE	102004026179	B4	1/2009	JP	H06343644	A	12/1994
DE	102008018406	B3	7/2009	JP	H07265328	A	10/1995
EP	0364216	A1	4/1990	JP	H0856955	A	3/1996
EP	0467501	A1	1/1992	JP	08252263	A	10/1996
EP	0509670	A3	12/1992	JP	8289895	A	11/1996
EP	0518230	A1	12/1992	JP	8317934	A	12/1996
EP	0306123	B1	8/1993	JP	8317936	A	12/1996
EP	0572131	A1	12/1993	JP	09000538	A	1/1997
EP	0584787	A1	3/1994	JP	H0910223	A	1/1997
EP	0589555	A1	3/1994	JP	9122138	A	5/1997
EP	0589453	A3	4/1994	JP	0010000195	A	1/1998
EP	0648475	A1	4/1995	JP	10155798	A	6/1998
EP	0624348	A3	6/1995	JP	1147149		2/1999
EP	0517243	B1	9/1997	JP	11070124	A	3/1999
EP	0541930	B1	3/1998	JP	11169381	A	6/1999
EP	0853922	A1	7/1998	JP	11192238	A	7/1999
EP	0878169	A1	11/1998	JP	H11244298	A	9/1999
EP	0623316	B1	3/1999	JP	2000102545	A	4/2000
EP	0650701	B1	3/1999	JP	2000135222	A	5/2000
EP	0923907	A1	6/1999	JP	2000342599	A	12/2000
EP	0640317	B1	9/1999	JP	2000350732	A	12/2000
EP	0986990	A1	3/2000	JP	2001003400	A	1/2001
EP	1034747	A1	9/2000	JP	2001008944		1/2001
EP	1034748	A1	9/2000	JP	2001029355		2/2001
EP	0694290	B1	11/2000	JP	2001029356		2/2001
EP	1050278	A1	11/2000	JP	2001128990	A	5/2001
EP	1053719	A1	11/2000	JP	2001190564	A	7/2001
EP	1053720	A1	11/2000	JP	2002136525	A	5/2002
EP	1055399	A1	11/2000	JP	2002528166	A	9/2002
EP	1055400	A1	11/2000	JP	2003116871	A	4/2003
EP	1080694	A1	3/2001	JP	2003175052	A	6/2003
EP	1082944	A1	3/2001	JP	2003245285	A	9/2003
EP	1177771	A1	2/2002	JP	2004517668	A	6/2004
EP	1281878	A1	2/2003	JP	2004528869	A	9/2004
EP	1159926	A2	3/2003	JP	2004532676	A	10/2004
EP	0717966	B1	4/2003	JP	2005152663	A	6/2005
EP	1301135	A1	4/2003	JP	2005523380	A	8/2005
EP	0887046	B1	7/2003	JP	2005253789	A	9/2005
EP	1330991	A1	7/2003	JP	2005312807	A	11/2005
EP	1472984	A1	11/2004	JP	2006015078	A	1/2006
EP	0754437	B2	12/2004	JP	2006501939	A	1/2006
EP	1025807	B1	12/2004	JP	2006095316	A	4/2006
EP	1486177	A2	12/2004	JP	2007098139	A	4/2007
EP	0774232	B1	1/2005	JP	2008054926	A	3/2008
EP	1527747	A2	5/2005	JP	2011125195	A	6/2011
EP	1530952	A1	5/2005	JP	000603945	B2	11/2016
EP	1532932	A1	5/2005	JP	6502328	B2	4/2019
EP	1535581	A2	6/2005	SU	401367	A1	10/1973
EP	1609430	A1	12/2005	WO	8900757	A1	1/1989
EP	1034746	B1	3/2006	WO	9204873	A1	4/1992
EP	1632192	A1	3/2006	WO	9206642	A1	4/1992
EP	1642543	A1	4/2006	WO	9321845	A1	11/1993
				WO	9408524	A1	4/1994
				WO	9420025	A1	9/1994
				WO	9502369	A1	1/1995
				WO	9507662	A1	3/1995

(56)

## References Cited

## FOREIGN PATENT DOCUMENTS

WO 9515124 A1 6/1995  
 WO 9605776 A1 2/1996  
 WO 9613218 A1 5/1996  
 WO 9622056 A1 7/1996  
 WO 9700646 A1 1/1997  
 WO 9700647 A1 1/1997  
 WO 9710764 A1 3/1997  
 WO 9724073 A1 7/1997  
 WO 9724993 A1 7/1997  
 WO 9827880 A1 7/1998  
 WO 9903407 A1 1/1999  
 WO 9903408 A1 1/1999  
 WO 9903409 A1 1/1999  
 WO 9912488 A1 3/1999  
 WO 9923933 A2 5/1999  
 WO 9940857 A1 8/1999  
 WO 9940861 A1 8/1999  
 WO 9951158 A1 10/1999  
 WO 9966850 A1 12/1999  
 WO 0024330 A1 5/2000  
 WO 0024331 A1 5/2000  
 WO 0036986 A1 6/2000  
 WO 0041638 A1 7/2000  
 WO 0047124 A1 8/2000  
 WO 0053112 A2 9/2000  
 WO 0059392 A1 10/2000  
 WO 0115614 A1 3/2001  
 WO 0117448 A2 3/2001  
 WO 0154604 A1 8/2001  
 WO 0207627 1/2002  
 WO 0245589 A2 6/2002  
 WO 02067798 A1 9/2002  
 WO 02080783 A1 10/2002  
 WO 02080784 A1 10/2002  
 WO 02080785 A1 10/2002  
 WO 02080786 A1 10/2002  
 WO 02080793 A1 10/2002  
 WO 02080794 A1 10/2002  
 WO 02080795 A1 10/2002  
 WO 02080796 A1 10/2002  
 WO 02080797 A1 10/2002  
 WO 02080798 A1 10/2002  
 WO 02080799 A1 10/2002  
 WO 02081170 A1 10/2002  
 WO 02085218 A1 10/2002  
 WO 02094746 A1 11/2002  
 WO 03061500 A2 7/2003  
 WO 2003055449 A1 7/2003  
 WO 03068046 A2 8/2003  
 WO 03090630 A2 11/2003  
 WO 03096880 A2 11/2003  
 WO 03101311 A1 12/2003  
 WO 2004028585 A2 4/2004  
 WO 2004032776 A1 4/2004  
 WO 2004032777 A1 4/2004  
 WO 2004052221 A1 6/2004  
 WO 2004073488 A2 9/2004  
 WO 2004073490 A2 9/2004  
 WO 2004073753 A2 9/2004  
 WO 2004082495 A1 9/2004  
 WO 2004083797 A2 9/2004  
 WO 2004098383 A2 11/2004  
 WO 2004103156 A2 12/2004  
 WO 2005004734 A1 1/2005  
 WO 2005004735 A1 1/2005  
 WO 2005009255 A1 2/2005  
 WO 2006021269 A1 3/2006  
 WO 2005110264 A2 4/2006  
 WO 2008008457 A2 1/2008  
 WO 2008040483 A1 4/2008  
 WO 2008045348 A2 4/2008  
 WO 2008045350 A2 4/2008  
 WO 20080112147 A1 9/2008  
 WO 20090005850 A1 1/2009  
 WO 2009039179 A1 3/2009

WO 2009039510 A1 3/2009  
 WO 2009124097 A1 10/2009  
 WO 2010104753 A1 9/2010  
 WO 2011018154 A1 2/2011

## OTHER PUBLICATIONS

International Search Report PCT/US01/11224 dated Nov. 13, 2001.  
 International Search Report EP 98958575.7 dated Sep. 20, 2002.  
 International Search Report EP 04013772 dated Apr. 1, 2005.  
 International Search Report EP 05013895 dated Oct. 14, 2005.  
 International Search Report EP 05017281 dated Nov. 16, 2005.  
 Int'l Search Report EP 05016399 dated Jan. 5, 2006.  
 Int'l Search Report EP 06005185.1 dated Apr. 18, 2006.  
 Int'l Search Report EP 06008779.8 dated Jun. 13, 2006.  
 Int'l Search Report EP 1683496 dated Jun. 13, 2006.  
 Int'l Search Report EP 06014461.5 dated Oct. 20, 2006.  
 Int'l Search Report EP 06020584.6 dated Jan. 12, 2007.  
 Int'l Search Report EP 06020583.8 dated Jan. 30, 2007.  
 Int'l Search Report EP 06020756.0 dated Feb. 5, 2007.  
 Int'l Search Report EP 06024123.9 dated Feb. 26, 2007.  
 Int'l Search Report EP 06 024122.1 dated Mar. 19, 2007.  
 Int'l Search Report EP 07 001480.8 dated Apr. 12, 2007.  
 Int'l Search Report EP 07 001488.1 dated May 29, 2007.  
 Int'l Search Report Extended—EP 07 009029.5 dated Jul. 12, 2007.  
 Int'l Search Report EP 07 009321.6 dated Aug. 17, 2007.  
 Japanese Office Action (with English translation), dated Aug. 31, 2016, corresponding to Japanese Application No. 2011-102433; 11 total pages.  
 Canadian Office Action and Examination Report, dated Sep. 23, 2016, corresponding to Canadian Application No. 2.738,240; 6 total pages.  
 U.S. Appl. No. 12/399,614, filed Mar. 6, 2009.  
 U.S. Appl. No. 12/195,624, filed Aug. 21, 2008.  
 U.S. Appl. No. 12/367,791, filed Feb. 9, 2009.  
 U.S. Appl. No. 12/361,367, filed Jan. 28, 2009.  
 U.S. Appl. No. 12/361,375, filed Jan. 28, 2009.  
 U.S. Appl. No. 12/400,901, filed Mar. 10, 2009.  
 U.S. Appl. No. 12/176,679, filed Jul. 21, 2008.  
 U.S. Appl. No. 12/237,515, filed Sep. 25, 2008.  
 U.S. Appl. No. 12/204,976, filed Sep. 5, 2008.  
 U.S. Appl. No. 12/192,170, filed Aug. 15, 2008.  
 U.S. Appl. No. 12/233,157, filed Sep. 18, 2008.  
 U.S. Appl. No. 12/237,582, filed Sep. 25, 2008.  
 U.S. Appl. No. 12/210,598, filed Sep. 15, 2008.  
 U.S. Appl. No. 12/200,154, filed Aug. 28, 2008.  
 U.S. Appl. No. 12/211,205, filed Sep. 16, 2008.  
 U.S. Appl. No. 12/244,873, filed Oct. 3, 2008.  
 U.S. Appl. No. 12/246,553, filed Oct. 7, 2008.  
 U.S. Appl. No. 12/248,115, filed Oct. 9, 2008.  
 U.S. Appl. No. 12/353,474, filed Jan. 14, 2009.  
 U.S. Appl. No. 12/353,470, filed Jan. 14, 2009.  
 U.S. Appl. No. 12/352,942, filed Jan. 13, 2009.  
 U.S. Appl. No. 12/237,556, filed Sep. 25, 2008.  
 U.S. Appl. No. 12/411,542, filed Mar. 26, 2009.  
 U.S. Appl. No. 12/248,104, filed Oct. 9, 2008.  
 U.S. Appl. No. 12/254,123, filed Oct. 20, 2008.  
 U.S. Appl. No. 12/200,246, filed Aug. 28, 2008.  
 U.S. Appl. No. 12/200,396, filed Aug. 28, 2008.  
 U.S. Appl. No. 12/200,526, filed Aug. 28, 2008.  
 McLellan et al. "Vessel Sealing for Hemostasis During Gynecologic Surgery" Sales/Product Literature 1999.  
 Int'l Search Report EP 98944778.4 dated Oct. 31, 2000.  
 Int'l Search Report EP 98957771 dated Aug. 9, 2001.  
 Int'l Search Report EP 98958575.7 dated Sep. 20, 2002.  
 Int'l Search Report EP 04027314.6 dated Mar. 10, 2005.  
 Int'l Search Report EP 04027479.7 dated Mar. 8, 2005.  
 Int'l Search Report EP 04027705.5 dated Feb. 3, 2005.  
 Int'l Search Report EP 04752343.6 dated Jul. 20, 2007.  
 Int'l Search Report EP 05002671.5 dated Dec. 22, 2008.  
 Int'l Search Report PCT/US99/24869 dated Feb. 3, 2000.  
 Int'l Search Report PCT/US01/11218 dated Aug. 14, 2001.  
 Int'l Search Report PCT/US01/11340 dated Aug. 16, 2001.

(56)

**References Cited**

## OTHER PUBLICATIONS

- Int'l Search Report PCT/US01/11420 dated Oct. 16, 2001.  
 Int'l Search Report PCT/US02/01890 dated Jul. 25, 2002.  
 Int'l Search Report PCT/US02/11100 dated Jul. 16, 2002.  
 Int'l Search Report PCT/US03/28534 dated Dec. 19, 2003.  
 Int'l Search Report PCT/US04/03436 dated Mar. 3, 2005.  
 Int'l Search Report PCT/US04/13273 dated Dec. 15, 2004.  
 Int'l Search Report PCT/US04/15311 dated Jan. 12, 2005.  
 Int'l Search Report PCT/US07/021438 dated Apr. 1, 2008.  
 Int'l Search Report PCT/US07/021440 dated Apr. 8, 2008.  
 Int'l Search Report PCT/US08/61498 dated Sep. 22, 2008.  
 Int'l Search Report PCT/US09/032690 dated Jun. 16, 2009.  
 International Search Report EP06008515.6 dated Jan. 8, 2009.  
 Official Action issued by the Canadian Patent Office in co-pending Canadian Patent Application No. 2,442,598 dated Nov. 3, 2009.  
 European Search Report dated Aug. 31, 2011 for EP Appln. No. EP 10 16 7655.  
 US 6,090,109, 07/2000, Lands et al. (withdrawn)  
 US 6,663,629, 12/2003, Buysse et al. (withdrawn)  
 Crawford et al. "Use of the LigaSure Vessel Sealing System in Urologic Cancer Surger"; Grand Rounds in Urology 1999 vol. 1 Issue 4 pp. 10-17.  
 Int'l Search Report PCT/US01/11218.  
 Int'l Search Report PCT/US99/24869.  
 Int'l Search Report PCT/US98/18640.  
 Int'l Search Report PCT/US98/23950.  
 "Innovations in Electrosurgery" Sales/Product Literature.  
 Carbonell et al., "Comparison of theGyrus PlasmaKinetic Sealer and the Valleylab LigaSure Device in the Hemostasis of Small, Medium, and Large-Sized Arteries" Carolinas Laparoscopic and Advanced Surgery Program, Carolinas Medical Center, Charlotte, NC.  
 PCT/US01/11340, International Search Report.  
 PCT/US01/11420, International Search Report.  
 PCT/US02/01890, International Search Report.  
 PCT/US02/11100, International Search Report.  
 PCT/US04/03436, International Search Report.  
 PCT/US04/13273, International Search Report.  
 PCT/US04/15311, International Search Report.  
 EP 98944778, International Search Report.  
 EP 98958575, International Search Report.  
 EP 04027479, International Search Report.  
 EP 04027705, International Search Report.  
 EP 04027314, International Search Report.  
 Int'l Search Report EP 05013463.4 dated Sep. 28, 2005.  
 Int'l Search Report EP 05019130.3 dated Oct. 18, 2005.  
 Int'l Search Report EP 05020665.5 dated Feb. 16, 2006.  
 Int'l Search Report EP 05020666.3 dated Feb. 17, 2006.  
 Int'l Search Report EP 05021779.3 dated Jan. 18, 2006.  
 Int'l Search Report EP 05021197.8 dated Jan. 31, 2006.  
 Int'l Search Report EP 05021937.7 dated Jan. 13, 2006.  
 Int'l Search Report—extended—EP 05021937.7 dated Mar. 6, 2006.  
 Int'l Search Report EP 05023017.6 dated Feb. 16, 2006.  
 Int'l Search Report EP 05021780.1 dated Feb. 9, 2006.  
 Int'l Search Report EP 06002279.5 dated Mar. 22, 2006.  
 "Innovations in Electrosurgery" Sales/Product Literature; Dec. 31, 2000.  
 U.S. Appl. No. 12/236,666, filed Sep. 24, 2008.  
 U.S. Appl. No. 12/192,189, filed Aug. 15, 2008.  
 U.S. Appl. No. 12/192,243, filed Aug. 15, 2008.  
 U.S. Appl. No. 12/331,643, filed Dec. 10, 2008.  
 U.S. Appl. No. 12/353,466, filed Jan. 14, 2009.  
 U.S. Appl. No. 12/363,086, filed Jan. 30, 2009.  
 U.S. Appl. No. 12/419,729, filed Apr. 7, 2009.  
 "Reducing Needlestick Injuries in the Operating Room"; Sales/Product Literature 2001.  
 U.S. Appl. No. 12/336,970, filed Dec. 17, 2008, Sremcich, Abandoned.  
 Int'l Search Report EP 05002674.9 dated Jan. 16, 2009.  
 Int'l Search Report EP 05013463.4 dated Oct. 7, 2005.  
 Int'l Search Report EP 05013895.7 dated Oct. 21, 2005.  
 Int'l Search Report EP 05016399.7 dated Jan. 13, 2006.  
 Int'l Search Report EP 05017281.6 dated Nov. 24, 2005.  
 Int'l Search Report EP 05019130.3 dated Oct. 27, 2005.  
 Int'l Search Report EP 05019429.9 dated May 6, 2008.  
 Int'l Search Report EP 05020665.5 dated Feb. 27, 2006.  
 Int'l Search Report EP 05020666.3 dated Feb. 27, 2006.  
 Int'l Search Report EP 05021197.8 dated Feb. 20, 2006.  
 Int'l Search Report EP 05021779.3 dated Feb. 2, 2006.  
 Int'l Search Report EP 05021780.1 dated Feb. 23, 2006.  
 Int'l Search Report EP 05021937.7 dated Jan. 23, 2006.  
 Int'l Search Report—extended—EP 05021937.7 dated Mar. 15, 2006.  
 Int'l Search Report EP 05023017.6 dated Feb. 24, 2006.  
 Int'l Search Report EP 06002279.5 dated Mar. 30, 2006.  
 Int'l Search Report EP 06005185.1 dated May 10, 2006.  
 Int'l Search Report EP 06006716.2 dated Aug. 4, 2006.  
 Int'l Search Report EP 06008515.6 dated Jan. 8, 2009.  
 Int'l Search Report EP 06008779.8 dated Jul. 13, 2006.  
 Int'l Search Report EP 06014461.5 dated Oct. 31, 2006.  
 Int'l Search Report EP 06020574.7 dated Oct. 2, 2007.  
 Int'l Search Report EP 06020583.8 dated Feb. 7, 2007.  
 Int'l Search Report EP 06020584.6 dated Feb. 1, 2007.  
 Int'l Search Report EP 06020756.0 dated Feb. 16, 2007.  
 Int'l Search Report EP 06 024122.1 dated Apr. 16, 2007.  
 Int'l Search Report EP 06024123.9 dated Mar. 6, 2007.  
 Int'l Search Report EP 07 001480.8 dated Apr. 19, 2007.  
 Int'l Search Report EP 07 001488.1 dated Jun. 5, 2007.  
 Int'l Search Report EP 07 009026.1 dated Oct. 8, 2007.  
 Int'l Search Report Extended—EP 07 009029.5 dated Jul. 20, 2007.  
 Int'l Search Report EP 07 009321.6 dated Aug. 28, 2007.  
 Int'l Search Report EP 07 010672.9 dated Oct. 16, 2007.  
 Int'l Search Report EP 07 013779.9 dated Oct. 26, 2007.  
 Int'l Search Report EP 07 014016 dated Jan. 28, 2008.  
 Int'l Search Report EP 07 015191.5 dated Jan. 23, 2008.  
 Int'l Search Report EP 07 015601.3 dated Jan. 4, 2008.  
 Int'l Search Report EP 07 020283.3 dated Feb. 5, 2008.  
 Int'l Search Report EP 07 021646.0 dated Jul. 9, 2008.  
 Int'l Search Report EP 07 021647.8 dated May 2, 2008.  
 Int'l Search Report EP 08 002692.5 dated Dec. 12, 2008.  
 Int'l Search Report EP 08 004655.0 dated Jun. 24, 2008.  
 Int'l Search Report EP 08 006732.5 dated Jul. 29, 2008.  
 Int'l Search Report EP 08 006917.2 dated Jul. 3, 2008.  
 Int'l Search Report EP 08 016539.2 dated Jan. 8, 2009.  
 Int'l Search Report EP 09 152267.2 dated Jun. 15, 2009.  
 Int'l Search Report EP 09 152898.4 dated Jun. 10, 2009.  
 Int'l Search Report PCT/US98/18640 dated Jan. 29, 1999.  
 Int'l Search Report PCT/US98/23950 dated Jan. 14, 1999.  
 Int'l Search Report PCT/US98/24281 dated Feb. 22, 1999.  
 U.S. Appl. No. 12/336,970, filed Dec. 17, 2008.  
 Michael Choti, "Abdominoperineal Resection with the LigaSure Vessel Sealing System and LigaSure Atlas 20 cm Open Instrument" Innovations That Work, Jun. 2003.  
 Chung et al., "Clinical Experience of Sutureless Closed Hemorrhoidectomy with LigaSure" Diseases of the Colon & Rectum vol. 46, No. 1 Jan. 2003.  
 Carbonell et al., "Comparison of theGyrus PlasmaKinetic Sealer and the Valleylab LigaSure Device in the Hemostasis of Small, Medium, and Large-Sized Arteries" Carolinas Laparoscopic and Advanced Surgery Program, Carolinas Medical Center, Charlotte, NC; Date: Aug. 2003.  
 Peterson et al., "Comparison of Healing Process Following Ligation with Sutures and Bipolar Vessel Sealing" Surgical Technology International (2001).  
 "Electrosurgery: A Historical Overview" Innovations in Electrosurgery; Sales/Product Literature; Dec. 31, 2000, 6 pages.  
 Johnson et al. "Evaluation of a Bipolar Electrothermal Vessel Sealing Device in Hemorrhoidectomy" Sales/Product Literature; Jan. 2004.  
 E. David Crawford, "Evaluation of a New Vessel Sealing Device in Urologic Cancer Surgery" Sales/Product Literature 2000.

(56)

**References Cited**

## OTHER PUBLICATIONS

- Johnson et al. "Evaluation of the LigaSure Vessel Sealing System in Hemorrhoidectomy" American College of Surgeons (ACS) Clinica Congress Poster (2000).
- Muller et al. "Extended Left Hemicolectomy Using the LigaSure Vessel Sealing System" Innovations That Work; Sep. 1999.
- Kennedy et al. "High-burst-strength, feedback-controlled bipolar vessel sealing" *Surgical Endoscopy* (1998) 12:876-878.
- Carus et al., "Initial Experience With the LigaSure Vessel Sealing System in Abdominal Surgery" *Innovations That Work*, Jun. 2002.
- Heniford et al. "Initial Research and Clinical Results with an Electrothermal Bipolar Vessel Sealer" Oct. 1999.
- Heniford et al. "Initial Results with an Electrothermal Bipolar Vessel Sealer" *Surgical Endoscopy* (2000) 15:799-801. (4 pages).
- Herman et al., "Laparoscopic Intestinal Resection With the LigaSure Vessel Sealing System: A Case Report"; *Innovations That Work*, Feb. 2002.
- Koyle et al., "Laparoscopic Palomo Varicocele Ligation in Children and Adolescents" *Pediatric Endosurgery & Innovative Techniques*, vol. 6, No. 1, 2002.
- W. Scott Helton, "LigaSure Vessel Sealing System: Revolutionary Hemostasis Product for General Surgery"; *Sales/Product Literature* 1999.
- LigaSure Vessel Sealing System, the Seal of Confidence in General, Gynecologic, Urologic, and Laparoscopic Surgery; *Sales/Product Literature*; Apr. 2002.
- Joseph Ortenberg "LigaSure System Used in Laparoscopic 1st and 2nd Stage Orchiopexy" *Innovations That Work*, Nov. 2002.
- Sigel et al., "The Mechanism of Blood Vessel Closure by High Frequency Electrocoagulation" *Surgery Gynecology & Obstetrics*, Oct. 1965 pp. 823-831.
- Sampayan et al, "Multilayer Ultra-High Gradient Insulator Technology" *Discharges and Electrical Insulation in Vacuum*, 1998. Netherlands Aug. 17-21, 1998; vol. 2, pp. 740-743.
- Paul G. Horgan, "A Novel Technique for Parenchymal Division During Hepatectomy" *The American Journal of Surgery*, vol. 181, No. 3, Apr. 2001 pp. 236-237.
- Olsson et al. "Radical Cystectomy in Females". *Current Surgical Techniques in Urology*, vol. 14, Issue 3, 2001.
- Palazzo et al. "Randomized clinical trial of Ligasure versus open haemorrhoidectomy" *British Journal of Surgery* 2002, 89, 154-157.
- Levy et al. "Randomized Trial of Suture Versus Electrosurgical Bipolar Vessel Sealing in Vaginal Hysterectomy" *Obstetrics & Gynecology*, vol. 102, No. 1, Jul. 2003.
- "Reducing Needlestick Injuries in the Operating Room" *Sales/Product Literature* 2001. (1 page).
- Bergdahl et al., "Studies on Coagulation and the Development of an Automatic Computerized Bipolar Coagulator" *J. Neurosurg*, vol. 75, Jul. 1991, pp. 148-151.
- Strasberg et al. "A Phase I Study of the LigaSure Vessel Sealing System in Hepatic Surgery" Section of HPB Surger, Washington University School of Medicine, St. Louis MO, Presented at AHPBA, Feb. 2001.
- Sayfan et al., "Sutureless Closed Hemorrhoidectomy: A New Technique" *Annals of Surgery*, vol. 234, No. 1, Jul. 2001, pp. 21-24.
- Levy et al., "Update on Hysterectomy—New Technologies and Techniques" *OBG Management*, Feb. 2003.
- Dulemba et al. "Use of a Bipolar Electrothermal Vessel Sealer in Laparoscopically Assisted Vaginal Hysterectomy" *Sales/Product Literature*; Jan. 2004.
- Strasberg et al., "Use of a Bipolar Vessel-Sealing Device for Parenchymal Transection During Liver Surgery" *Journal of Gastrointestinal Surgery*, vol. 6, No. 4, Jul./Aug. 2002 pp. 569-574.
- Sengupta et al., "Use of a Computer-Controlled Bipolar Diathermy System in Radical Prostatectomies and Other Open Urological Surgery" *ANZ Journal of Surgery* (2001) 71.9 pp. 538-540.
- Rothenberg et al. "Use of the LigaSure Vessel Sealing System in Minimally Invasive Surgery in Children" *Int'l Pediatric Endosurgery Group (IPEG)* 2000.
- Craig Johnson, "Use of the LigaSure Vessel Sealing System in Bloodless Hemorrhoidectomy"; *Innovations That Work*, Mar. 2000.
- Levy et al. "Use of a New Energy-based Vessel Ligation Device During Vaginal Hysterectomy"; *Int'l Federation of Gynecology and Obstetrics (FIGO) World Congress* 1999.
- Barbara Levy, "Use of a New Vessel Ligation Device During Vaginal Hysterectomy" *FIGO 2000*, Washington, D.C.. (1 page).
- E. David Crawford, "Use of a Novel Vessel Sealing Technology in Management of the Dorsal Veinous Complex" *Sales/Product Literature* 2000.
- Jarrett et al., "Use of the LigaSure Vessel Sealing System for Peri-Hilar Vessels in Laparoscopic Nephrectomy"; *Sales/Product Literature* 2000.
- Crouch et al. "A Velocity-Dependent Model for Needle Insertion in Soft Tissue"; *MICCAI 2005; LNCS 3750* pp. 624-632, Dated: 2005.
- McLellan et al., "Vessel Sealing for Hemostasis During Pelvic Surgery" *Int'l Federation of Gynecology and Obstetrics FIGO World Congress* 2000, Washington, DC.

\* cited by examiner



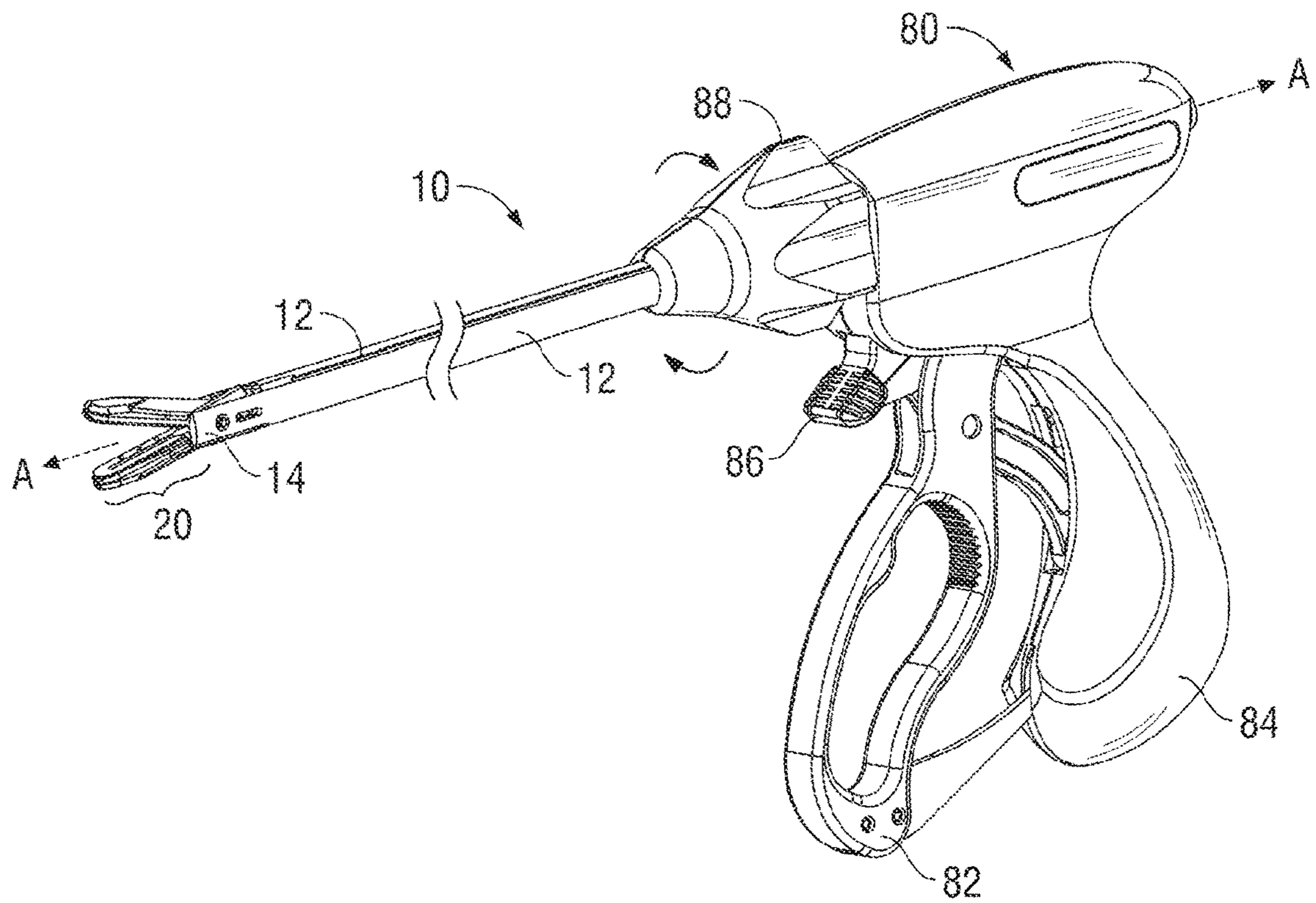


FIG. 1

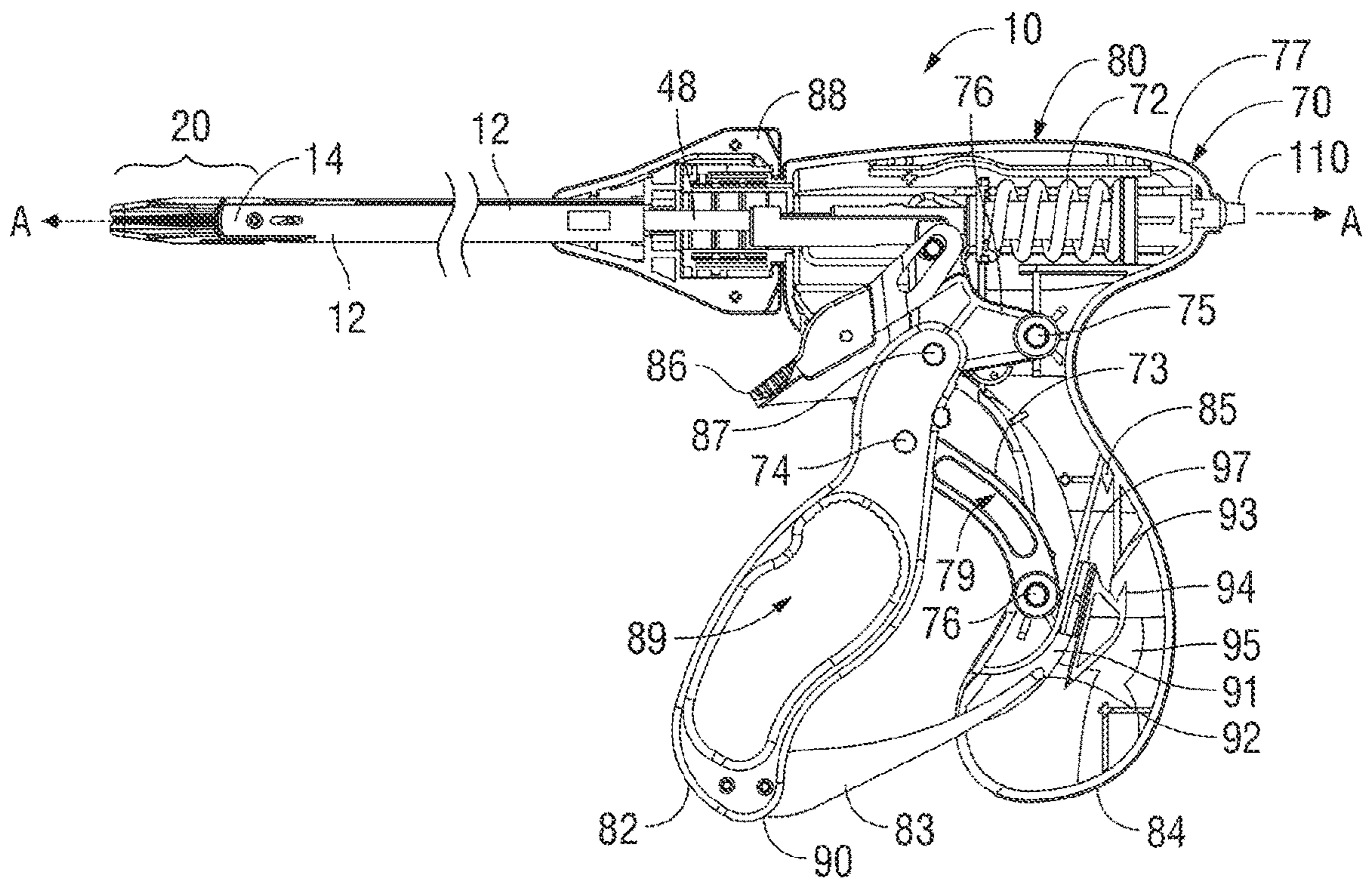


FIG. 2

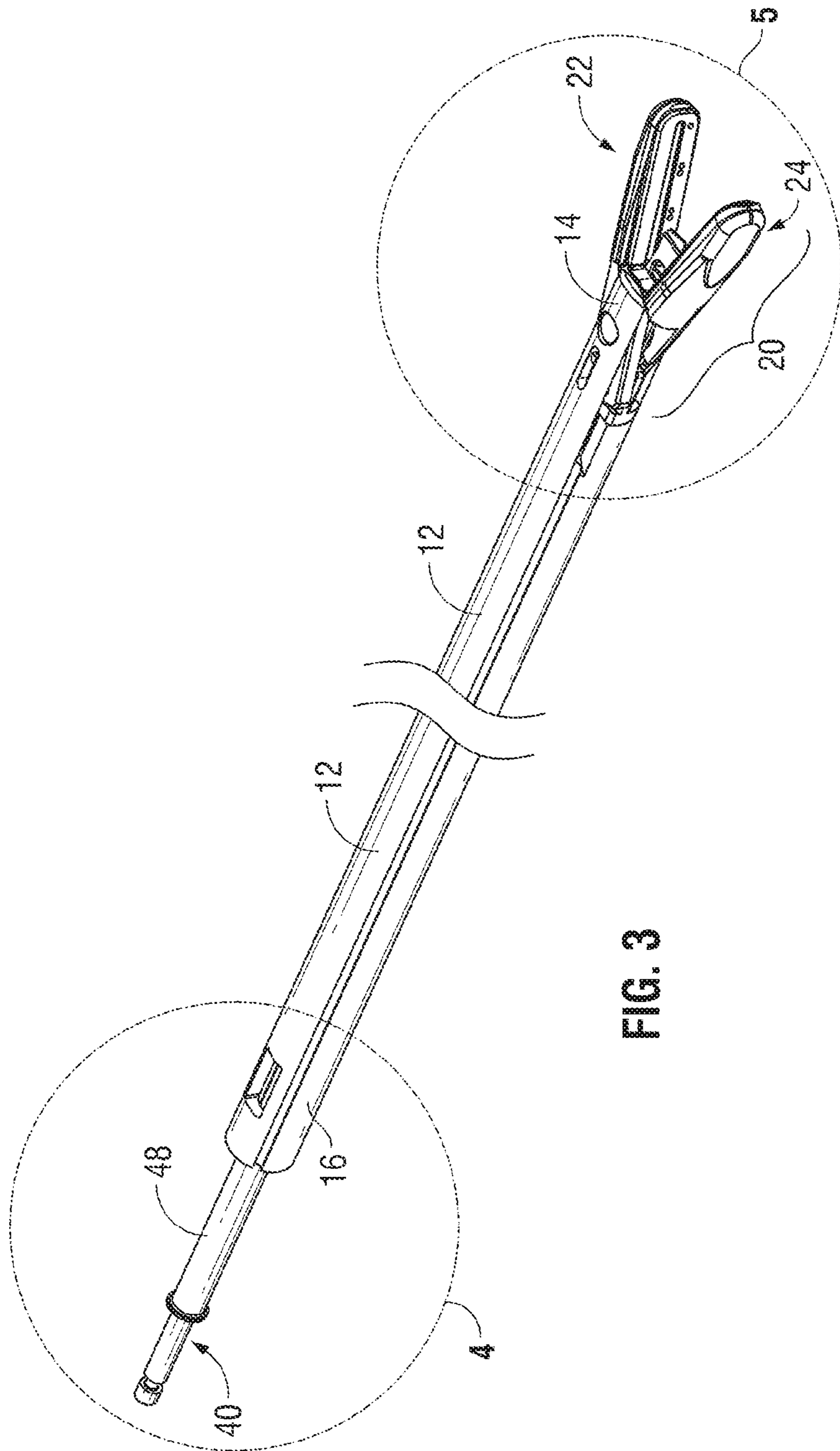


FIG. 3

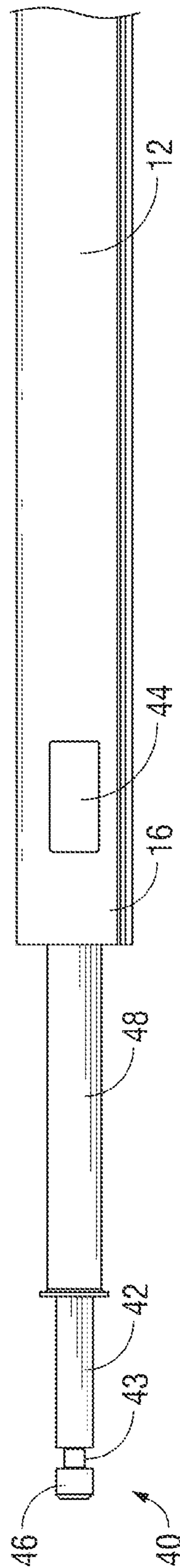


FIG. 4

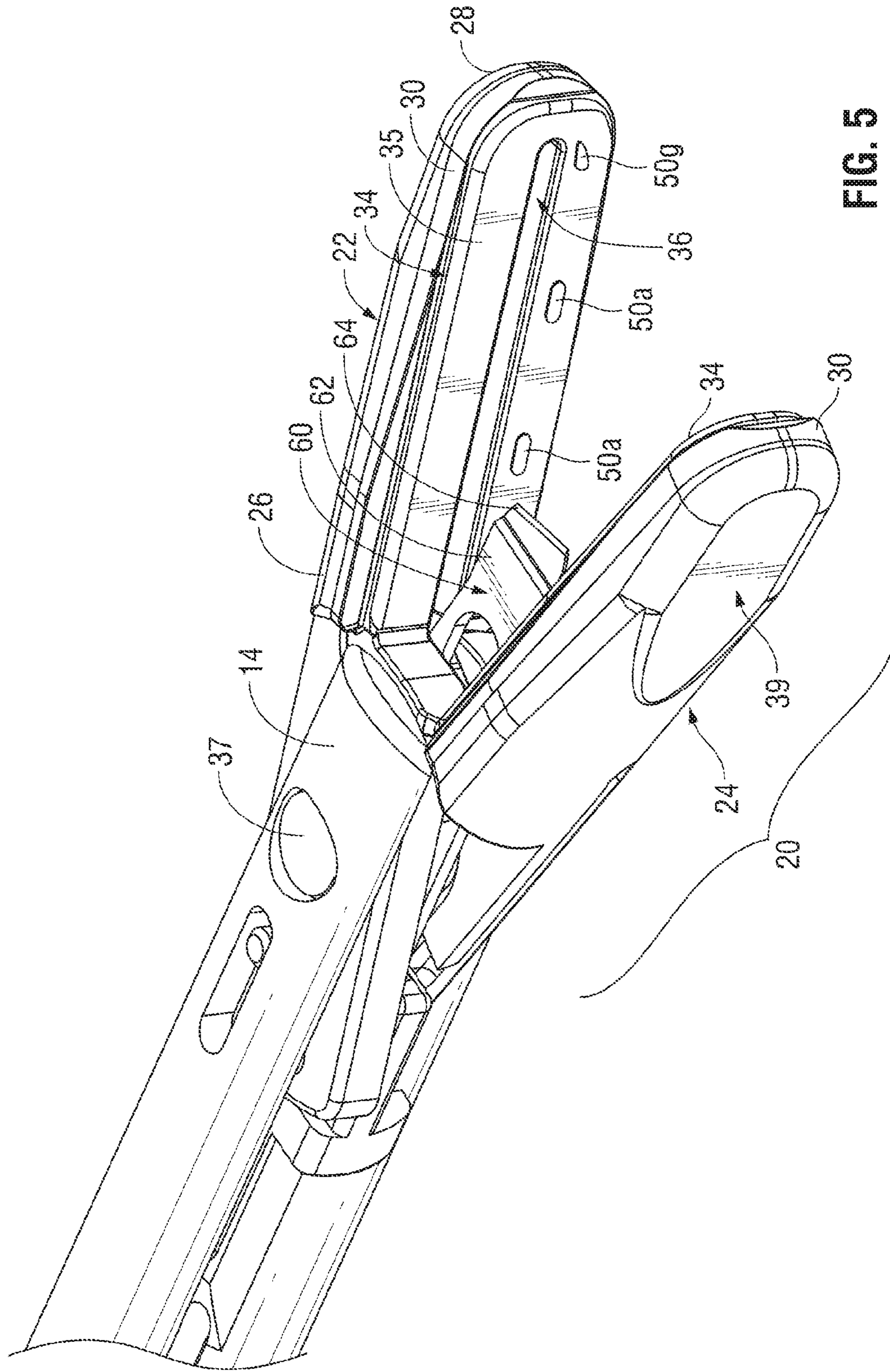


FIG. 5

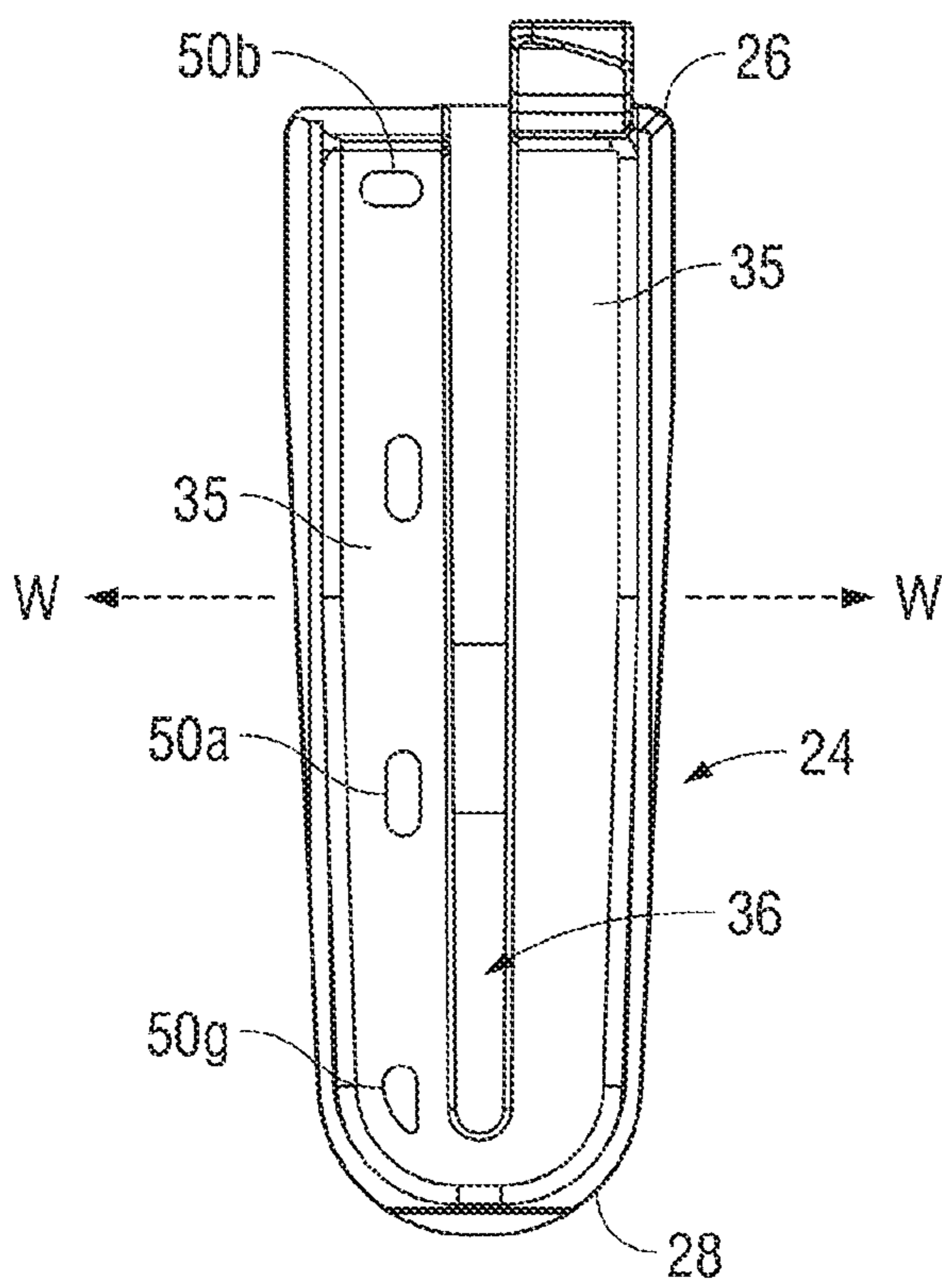


FIG. 6A

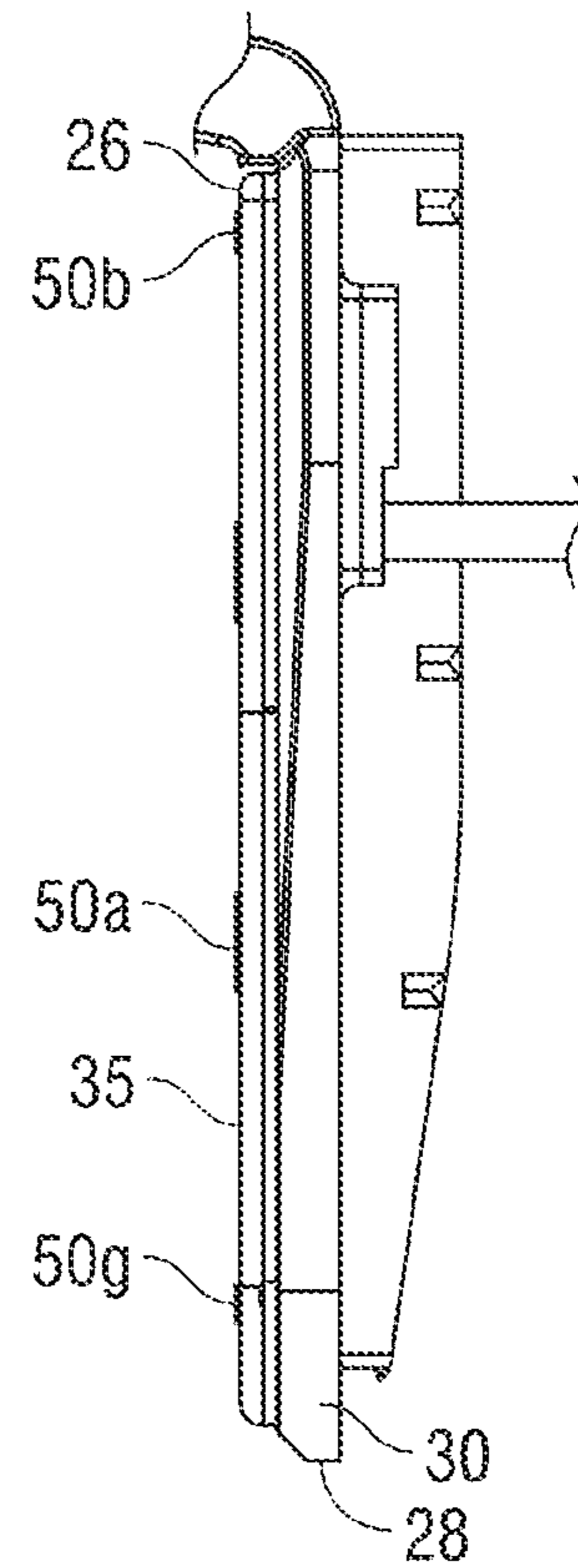


FIG. 6B

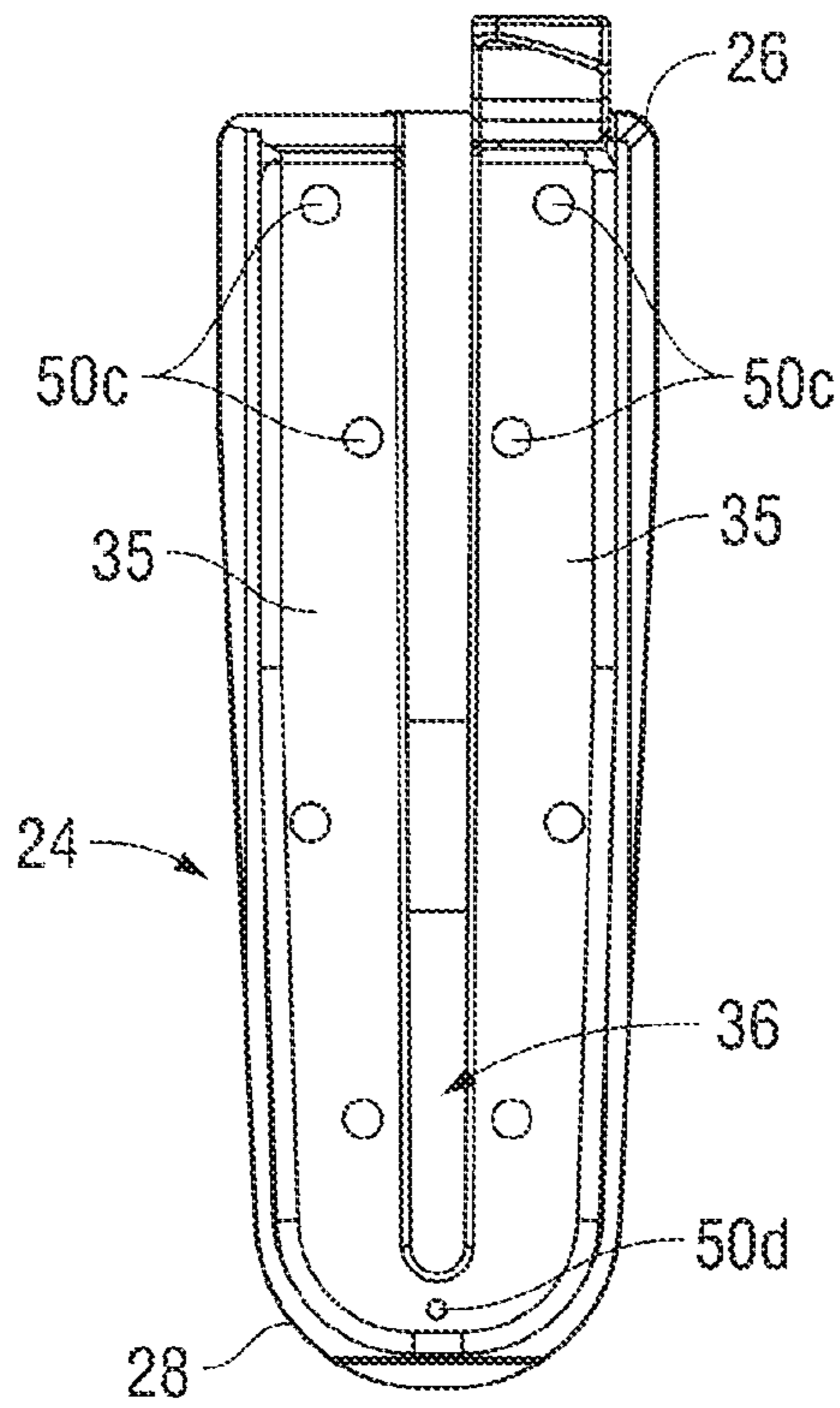


FIG. 6C

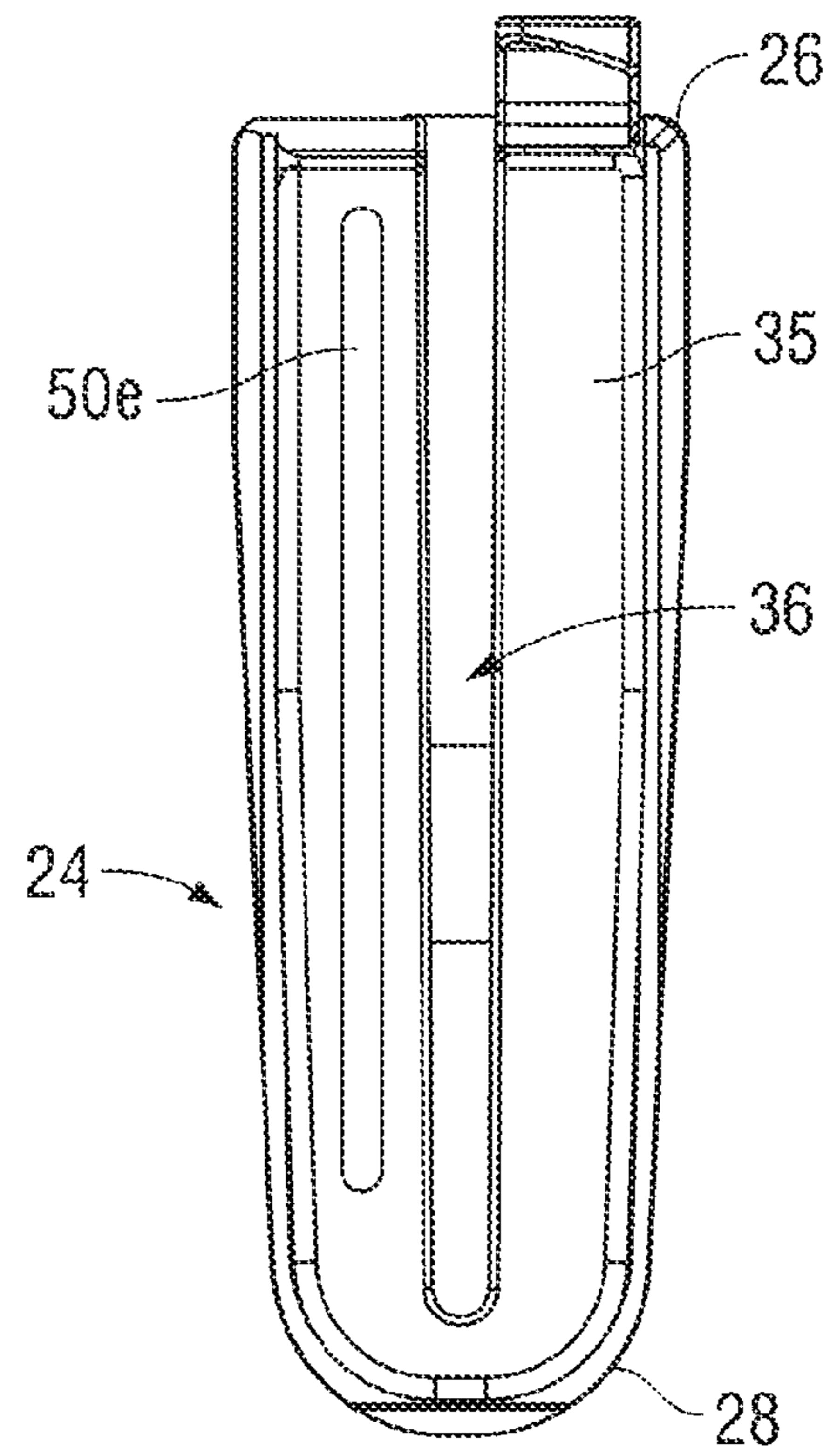


FIG. 6D

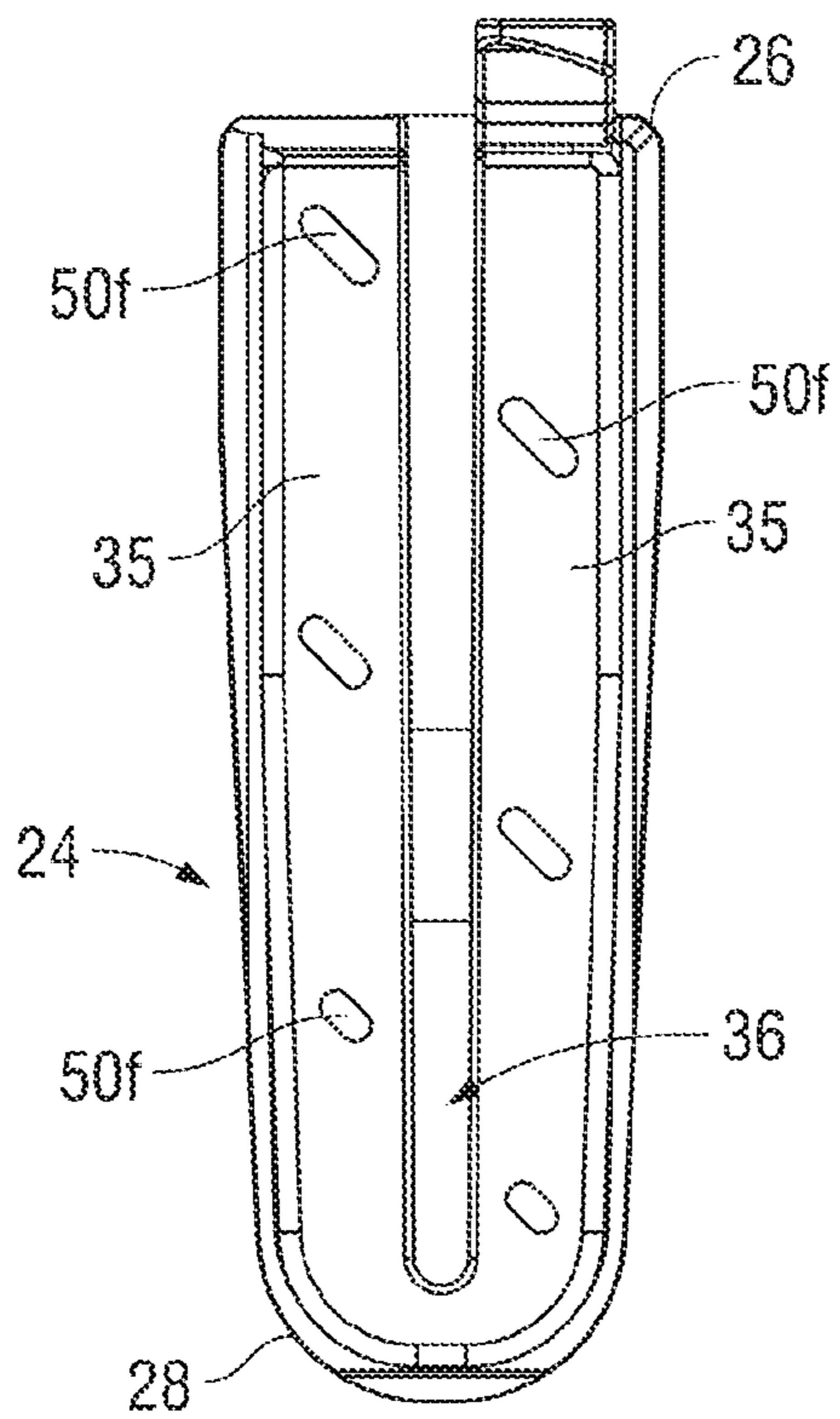


FIG. 6E

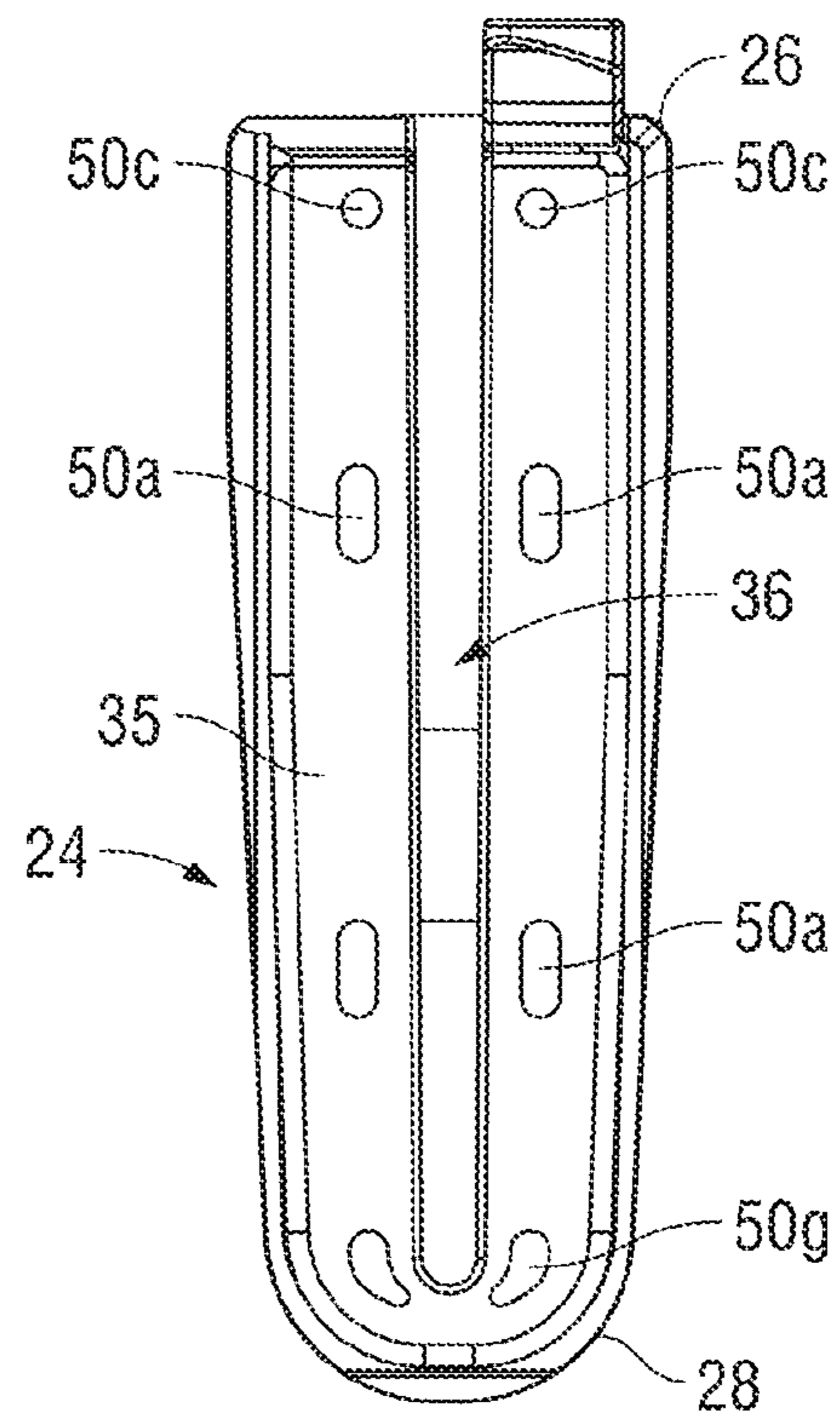


FIG. 6F

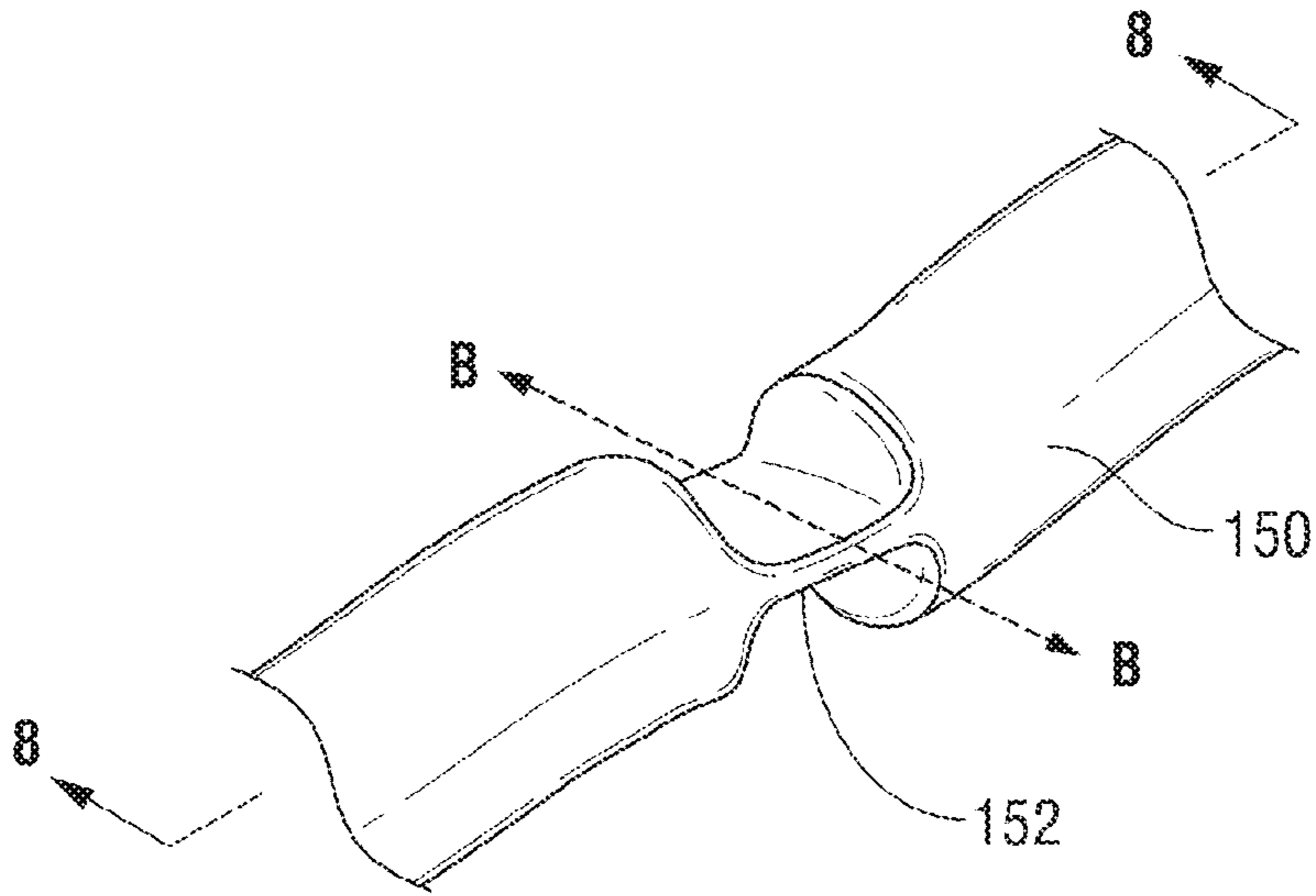


FIG. 7

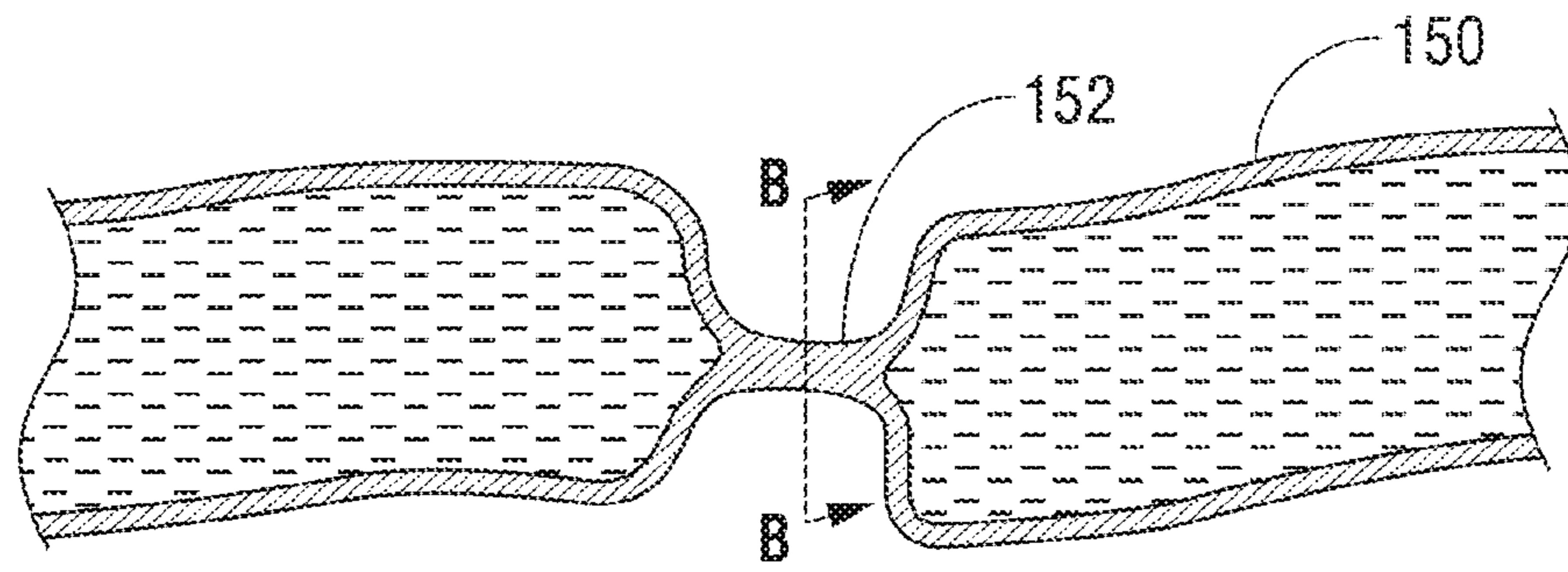


FIG. 8

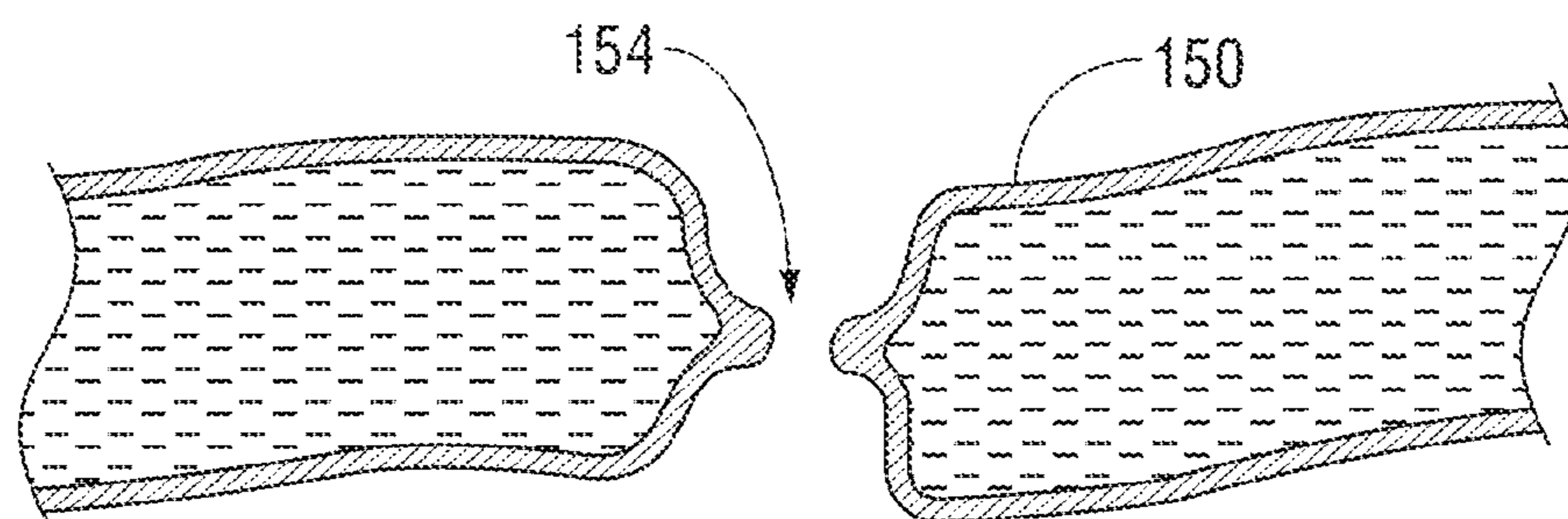


FIG. 9

**VESSEL SEALER AND DIVIDER****CROSS-REFERENCE TO RELATED APPLICATIONS**

This application is a continuation of U.S. application Ser. No. 16/053,052, filed on Aug. 2, 2018, now U.S. Pat. No. 10,265,121, which is a continuation of U.S. application Ser. No. 15/911,739, filed on Mar. 5, 2018, now U.S. Pat. No. 10,251,696, which is a continuation of U.S. application Ser. No. 15/338,663, filed on Oct. 31, 2016, which is a continuation of U.S. application Ser. No. 14/719,887, filed on May 22, 2015, which is a continuation of U.S. application Ser. No. 13/584,194, filed on Aug. 13, 2012, which is a continuation of U.S. application Ser. No. 12/348,748, filed on Jan. 5, 2009, now U.S. Pat. No. 8,241,284, which is a continuation of U.S. application Ser. No. 10/471,818, filed on Sep. 11, 2003, now U.S. Pat. No. 7,473,253, which claims the benefit of and priority to PCT Application Serial No. PCT/US01/11413, filed Apr. 6, 2001, entitled "VESSEL SEALER AND DIVIDER WITH NON-CONDUCTIVE STOP MEMBERS", the entire contents of each of these applications is hereby incorporated by reference.

**BACKGROUND**

The present disclosure relates to an electro-surgical instrument and method for performing endoscopic surgical procedures. More particularly, the present disclosure relates to an endoscopic bipolar electro-surgical forceps and method of using same which includes a non-conductive stop member associated with one or both of the opposing jaw members. The non-conductive stop member is designed to control the gap distance between opposing jaw members and enhance the manipulation and gripping of tissue during the sealing and dividing process.

**TECHNICAL FIELD**

Endoscopic forceps utilize mechanical action to constrict, grasp, dissect and/or clamp tissue. Endoscopic electro-surgical forceps utilize both mechanical clamping action and electrical energy to effect hemostasis by heating the tissue and blood vessels to coagulate, cauterize and/or seal tissue.

Endoscopic instruments are inserted into the patient through a cannula, or port, that has been made with a trocar or similar such device. Typical sizes for cannulas range from three millimeters to twelve millimeters. Smaller cannulas are usually preferred, and this presents a design challenge to instrument manufacturers who must find ways to make surgical instruments that fit through the cannulas.

Certain endoscopic surgical procedures require cutting blood vessels or vascular tissue. However, due to space limitations surgeons can have difficulty suturing vessels or performing other traditional methods of controlling bleeding, e.g., clamping and/or tying-off transected blood vessels. Blood vessels, in the range below two millimeters in diameter, can often be closed using standard electro-surgical techniques. However, if a larger vessel is severed, it may be necessary for the surgeon to convert the endoscopic procedure into an open-surgical procedure and thereby abandon the benefits of laparoscopy.

Several journal articles have disclosed methods for sealing small blood vessels using electro-surgery. An article entitled Studies on Coagulation and the Development of an Automatic Computerized Bipolar Coagulator, J. Neurosurg., Volume 75, July 1991, describes a bipolar coagulator which

is used to seal small blood vessels. The article states that it is not possible to safely coagulate arteries with a diameter larger than 2 to 2.5 mm. A second article is entitled Automatically Controlled Bipolar Electrocoagulation—"COA-COMP", Neurosurg. Rev. (1984), pp. 187-190, describes a method for terminating electro-surgical power to the vessel so that charring of the vessel walls can be avoided.

As mentioned above, by utilizing an electro-surgical forceps, a surgeon can either cauterize, coagulate/desiccate and/or simply reduce or slow bleeding, by controlling the intensity, frequency and duration of the electro-surgical energy applied through the jaw members to the tissue. The electrode of each jaw member is charged to a different electric potential such that when the jaw members grasp tissue, electrical energy can be selectively transferred through the tissue.

In order to effect a proper seal with larger vessels, two predominant mechanical parameters must be accurately controlled—the pressure applied to the vessel and the gap distance between the electrodes—both of which are affected by the thickness of the sealed vessel. More particularly, accurate application of pressure is important to oppose the walls of the vessel; to reduce the tissue impedance to a low enough value that allows enough electro-surgical energy through the tissue; to overcome the forces of expansion during tissue heating; and to contribute to the end tissue thickness which is an indication of a good seal. It has been determined that a typical fused vessel wall is optimum between 0.001 and 0.005 inches. Below this range, the seal may shred or tear and above this range the lumens may not be properly or effectively sealed.

Electro-surgical methods may be able to seal larger vessels using an appropriate electro-surgical power curve, coupled with an instrument capable of applying a large closure force to the vessel walls. It is thought that the process of coagulating small vessels is fundamentally different than electro-surgical vessel sealing. For the purposes herein, "coagulation" is defined as a process of desiccating tissue wherein the tissue cells are ruptured and dried. Vessel sealing is defined as the process of liquefying the collagen in the tissue so that it reforms into a fused mass. Thus, coagulation of small vessels is sufficient to permanently close them. Larger vessels need to be sealed to assure permanent closure.

U.S. Pat. No. 2,176,479 to Willis, U.S. Pat. Nos. 4,005,714 and 4,031,898 to Hildebrandt, U.S. Pat. Nos. 5,827,274, 5,290,287 and 5,312,433 to Boebel et al., U.S. Pat. Nos. 4,370,980, 4,552,143, 5,026,370 and 5,116,332 to Lottick, U.S. Pat. No. 5,443,463 to Stern et al., U.S. Pat. No. 5,484,436 to Eggers et al. and U.S. Pat. No. 5,951,549 to Richardson et al., all relate to electro-surgical instruments for coagulating, cutting and/or sealing vessels or tissue. However, some of these designs may not provide uniformly reproducible pressure to the blood vessel and may result in an ineffective or non-uniform seal.

For the most part, these instruments rely on clamping pressure alone to procure proper sealing thickness and are not designed to take into account gap tolerances and/or parallelism and flatness requirements which are parameters which, if properly controlled, can assure a consistent and effective tissue seal. For example, it is known that it is difficult to adequately control thickness of the resulting sealed tissue by controlling clamping pressure alone for either of two reasons: 1) if too much force is applied, there is a possibility that the two poles will touch and energy will not be transferred through the tissue resulting in an ineffective seal; or 2) if too low a force is applied the tissue may

pre-maturely move prior to activation and sealing and/or a thicker, less reliable seal may be created.

Typically and particularly with respect to endoscopic electro-surgical procedures, once a vessel is sealed, the surgeon has to remove the sealing instrument from the operative site, substitute a new instrument through the cannula and accurately sever the vessel along the newly formed tissue seal. As can be appreciated, this additional step may be both time consuming (particularly when sealing a significant number of vessels) and may contribute to imprecise separation of the tissue along the sealing line due to the misalignment or misplacement of the severing instrument along the center of the tissue sealing line.

Several attempts have been made to design an instrument which incorporates a knife or blade member which effectively severs the tissue after forming a tissue seal. For example, U.S. Pat. No. 5,674,220 to Fox et al. discloses a transparent vessel sealing instrument which includes a longitudinally reciprocating knife which severs the tissue once sealed. The instrument includes a plurality of openings which enable direct visualization of the tissue during the sealing and severing process. This direct visualization allows a user to visually and manually regulate the closure force and gap distance between jaw members to reduce and/or limit certain undesirable effects known to occur when sealing vessels, thermal spread, charring, etc. As can be appreciated, the overall success of creating a tissue seal with this instrument is greatly reliant upon the user's expertise, vision, dexterity, and experience in judging the appropriate closure force, gap distance and length of reciprocation of the knife to uniformly, consistently and effectively seal the vessel and separate the tissue at the seal.

U.S. Pat. No. 5,702,390 to Austin et al. discloses a vessel sealing instrument which includes a triangularly-shaped electrode which is rotatable from a first position to seal tissue to a second position to cut tissue. Again, the user must rely on direct visualization and expertise to control the various effects of sealing and cutting tissue.

Thus, a need exists to develop an endoscopic electro-surgical instrument which effectively and consistently seals and separates vascular tissue and solves the aforementioned problems. This instrument regulates the gap distances between opposing jaws members, reduces the chances of short circuiting the opposing jaws during activation and assists in manipulating, gripping and holding the tissue prior to and during activation and separation of the tissue.

#### SUMMARY

The present disclosure relates to an endoscopic bipolar electro-surgical forceps for clamping, sealing and/or dividing tissue. The forceps includes an elongated shaft having opposing jaw members at a distal end thereof. The jaw members are movable relative to one another from a first position wherein the jaw members are disposed in spaced relation relative to one another to a second position wherein the jaw members cooperate to grasp tissue therebetween. An electro-surgical energy source is connected to the jaw members such that the jaw members are capable of conducting energy through tissue held therebetween to effect a tissue seal. At least one non-conductive and spaced-apart stop member is disposed on an inner-facing surface of at least one of the jaw members and is positioned to control the gap distance between the opposing jaw members when the tissue is held therebetween. A longitudinally reciprocating knife severs the tissue proximate the sealing site once an effective seal is formed.

One embodiment of the presently disclosed forceps includes a drive rod assembly which connects the jaw members to the source of electrical energy such that the first jaw member has a first electrical potential and the second jaw member has a second electrical potential. Preferably, a handle mechanically engages the drive rod assembly and imparts movement of the first and second jaw members relative to one another.

In one embodiment of the present disclosure, one of the jaw members includes an electrically conductive surface having a longitudinally-oriented channel defined therein which facilitates longitudinal reciprocation of the knife for severing tissue. Preferably, the forceps includes a trigger for actuating the knife which is independently operable from the drive assembly.

In one embodiment, the forceps includes at least two stop members arranged as a series of longitudinally-oriented projections which extend along the inner-facing surface from the proximal end to the distal end of the jaw member. In another embodiment, the stop members include a series of circle-like tabs which project from the inner facing surface and extend from the proximal end to the distal end of the jaw member. The stop members may be disposed on either opposing jaw member on opposite sides of the longitudinally-oriented channel and/or in an alternating, laterally-offset manner relative to one another along the length of the surface of either or both jaw members.

In another embodiment of the present disclosure, a raised lip is provided to act as a stop member which projects from the inner-facing surface and extends about the outer periphery of the jaw member to control the gap distance between opposing jaw members. In another embodiment, at least one longitudinally-oriented ridge extends from the proximal end to the distal end of one of the jaw members and controls the gap distance between the jaw members.

Preferably, the stop members are affixed/attached to the jaw member(s) by stamping, thermal spraying, overmolding and/or by an adhesive. The stop members project from about 0.001 inches to about 0.005 inches and, preferably, from about 0.002 inches to about 0.003 inches from the inner-facing surface of at least one of the jaw members. It is envisioned that the stop members may be made from an insulative material such as parylene, nylon and/or ceramic. Other materials are also contemplated, e.g., syndiotactic polystyrenes such as QUESTRA® manufactured by DOW Chemical, Syndiotactic-polystyrene (SPS), Polybutylene Terephthalate (PBT), Polycarbonate (PC), Acrylonitrile Butadiene Styrene (ABS), Polyphthalamide (PPA), Polyimide, Polyethylene Terephthalate (PET), Polyamide-imide (PAI), Acrylic (PMMA), Polystyrene (PS and HIPS), Polyether Sulfone (PES), Aliphatic Polyketone, Acetal (POM) Copolymer, Polyurethane (PU and TPU), Nylon with Polyphenylene-oxide dispersion and Acrylonitrile Styrene Acrylate.

Another embodiment of the present disclosure includes an endoscopic bipolar forceps for sealing and dividing tissue having at least one elongated shaft having opposing jaw members at a distal end thereof. The jaw members are movable relative to one another from a first position wherein the jaw members are disposed in spaced relation relative to one another to a second position wherein the jaw members cooperate to grasp tissue therebetween. A drive rod assembly connects the jaw members to a source of electrical energy such that the first jaw member has a first electrical potential and the second jaw member has a second electrical potential. The jaw members, when activated, conduct energy through the tissue held between the jaw members to effect a



tissue seal. A handle attaches to the drive rod assembly and, when actuated, imparts movement of the first and second jaw members relative to one another via the drive rod assembly. At least one non-conductive and spaced-apart stop member is disposed on the inner facing surface of one of the jaw members and operates to control the overall gap distance between the opposing seal surfaces of the jaw members when tissue is held therebetween. A trigger mechanically activates a knife for severing the tissue proximate the tissue sealing site.

The present disclosure also relates to a method for sealing and dividing tissue and includes the steps of providing an endoscopic bipolar forceps which includes an elongated shaft having opposing jaw members at a distal end thereof which cooperate to grasp tissue therebetween, at least one non-conductive and spaced-apart stop member disposed on an inner facing surface of at least one of the jaw members which controls the distance between the jaw members when tissue is held therebetween, and a knife.

The method further includes the steps of: connecting the jaw members to a source of electrical energy; actuating the jaw members to grasp tissue between opposing jaw members; conducting energy to the jaw members to through tissue held therebetween to effect a seal; and actuating the knife to sever tissue proximate the seal.

Preferably, at least one of the jaw members of the providing step includes an electrically conductive surface having a longitudinally-oriented channel defined therein which facilitates actuation of the knife in a longitudinally reciprocating fashion within the channel for severing the tissue.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the subject instrument are described herein with reference to the drawings wherein:

FIG. 1 is a perspective view of an endoscopic forceps showing a handle and an end effector according to the present disclosure;

FIG. 2 is a partial cross-section of the forceps of FIG. 1 showing the internal working components of the handle and showing the end effector in a closed configuration;

FIG. 3 is an enlarged, perspective view of the end effector assembly shown in open configuration;

FIG. 4 is a greatly enlarged, side view of a proximal end of the end effector of FIG. 3;

FIG. 5 is a greatly enlarged perspective view of a distal end of the end effector of FIG. 3 showing a knife and a series of stop members disposed along an inner facing surface of a jaw member;

FIGS. 6A-6F show various configurations for the stop members on the inner facing surface of one of the jaw members;

FIG. 7 is an enlarged perspective view of a sealing site of a tubular vessel;

FIG. 8 is a longitudinal cross-section of the sealing site taken along line 8-8 of FIG. 7; and

FIG. 9 is a longitudinal cross-section of the sealing site of FIG. 7 after separation of the tubular vessel.

#### DETAILED DESCRIPTION

Referring now to FIGS. 1-5, one embodiment of an endoscopic bipolar forceps 10 is shown for use with various surgical procedures and includes a housing and handle assembly 80 having an end effector assembly 20 attached thereto. More particularly, forceps 10 includes a shaft 12 which has a distal end 14 dimensioned to mechanically

engage with the end effector assembly 20 and a proximal end 16 which mechanically engages the housing and handle assembly 80. In the drawings and in the descriptions which follow, the term “proximal”, as is traditional, will refer to the end of the forceps 10 which is closer to the user, while the term “distal” will refer to the end which is further from the user.

The end effector assembly 20 is attached to the distal end 14 of shaft 12 and includes a pair of opposing jaw members 22 and 24. Preferably, housing and handle assembly 80 is attached to the proximal end 16 of shaft 12 and includes internally-disposed activating mechanisms, e.g., a movable handle 82 and a drive assembly 70, which mechanically cooperate to impart movement of the jaw members 22 and 24 from an open position wherein the jaw members 22 and 24 are disposed in spaced relation relative to one another, to a clamping or closed position wherein the jaw members 22 and 24 cooperate to grasp tissue 150 (FIG. 7) therebetween.

It is envisioned that the forceps 10 may be designed such that it is fully or partially disposable depending upon a particular purpose or to achieve a particular result. For example, end effector assembly 20 may be selectively and releasably engageable with the distal end 14 of the shaft 12 and/or the proximal end 16 of the shaft 12 may be selectively and releasably engageable with the housing and handle assembly 80. In either of these two instances, the forceps 10 would be considered “partially disposable”, i.e., a new or different end effector assembly 20 (or end effector assembly 20 and shaft 12) selectively replaces the old end effector assembly 20 as needed.

FIGS. 1 and 2 show the operating elements and the internal-working components of the housing and handle assembly 80 which for the purposes of the present disclosure are generally described herein. The specific functions and operative relationships of these elements and the various internal-working components are described in more detail in commonly assigned, co-pending application U.S. Serial No. PCT/US01/11340, entitled “VESSEL SEALER AND DIVIDER” by Dycus et al. which is being filed concurrently herewith and which is hereby incorporated by reference herein in its entirety.

As best shown in FIG. 2, housing and handle assembly 80 includes movable handle 82 and a fixed handle 84. The movable handle 82 includes an aperture 89 defined there-through which enables a user to grasp and move the handle 82 relative to the fixed handle 84. Movable handle 82 is selectively moveable about a pivot 87 from a first position relative to fixed handle 84 to a second position in closer proximity to the fixed handle 84 which, as explained below, imparts relative movement of the jaw members 22 and 24 relative to one another.

More particularly, housing and handle assembly 80 houses a drive assembly 70 which cooperates with the movable handle 82 to impart movement of the jaw members 22 and 24 from an open position wherein the jaw members 22 and 24 are disposed in spaced relation relative to one another, to a clamping or closed position wherein the jaw members 22 and 24 cooperate to grasp tissue 150 (FIG. 7) therebetween. The general operating parameters of the drive assembly 70 and the internal-working components of the same are explained in a more generalized fashion below but are explained in specific detail in the above-mentioned commonly assigned, co-pending “VESSEL SEALER AND DIVIDER” application. For the purposes of the present disclosure, the housing and handle assembly 80 can generally be characterized as a four-bar mechanical linkage composed of the following elements: movable handle 82, a link

73, a cam-like link 76 and a base link embodied by fixed pivot points 75 and 76. Movement of the handle 82 activates the four-bar linkage which, in turn, actuates the drive assembly 70 for imparting movement of the opposing jaw members 22 and 24 relative to one another to grasp tissue 150 therebetween. It is envisioned that employing a four-bar mechanical linkage will enable the user to gain a significant mechanical advantage when compressing the jaw members 22 and 24 against the tissue 150 as explained in further detail below with respect to the generally disclosed operating parameters of the drive assembly 70.

Preferably, fixed handle 84 includes a channel 85 defined therein which is dimensioned to receive a flange 83 which extends proximally from movable handle 82. Preferably, flange 83 includes a fixed end 90 which is affixed to movable handle 82 and a free end 92 which is dimensioned for facile reception within channel 85 of handle 84. It is envisioned that flange 83 may be dimensioned to allow a user to selectively, progressively and incrementally move jaw members 22 and 24 relative to one another from the open to closed positions. For example, it is also contemplated that flange 83 may include a ratchet-like interface which lockingly engages the movable handle 82 and, therefore, jaw members 22 and 24 at selective, incremental positions relative to one another depending upon a particular purpose. Other mechanisms may also be employed to control and/or limit the movement of handle 82 relative to handle 84 (and jaw members 22 and 24) such as, e.g., hydraulic, semi-hydraulic and/or gearing systems.

As can be appreciated by the present disclosure and as explained in more detail with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application, channel 85 of fixed handle 84 includes an entrance pathway 91 and an exit pathway 95 for reciprocation of flange 83. As best shown in FIG. 2, as handle 82 moves in a generally pivoting fashion towards fixed handle 84 about pivot 87, link 73 rotates about a guide pin 74 disposed within handle 82. As a result, link 73 rotates proximally about a pivot 76. As can be appreciated, the pivoting path of handle 82 relative to fixed handle 84 biases cam-like link 76 to rotate about pivot 75 in a generally proximal direction. Movement of the cam-like link 76 imparts movement to the drive assembly 70 as explained below.

As best shown in FIG. 2, upon initial movement of handle 82 towards fixed handle 84, the free end 92 of flange 83 moves generally proximally and upwardly along entrance pathway 91 until end 92 passes or mechanically engages a rail member 97 disposed along pathway 91. It is envisioned that rail 97 permits movement of flange 83 proximally until the point where end 92 clears rail 97. Once end 92 clears rail 97, distal movement of the handle 82 and flange 83, i.e., release, is redirected by rail 97 into the exit pathway 95.

More particularly, upon initial release, i.e., a reduction in the closing pressure of handle 82 against handle 84, the handle 82 returns slightly distally towards pathway 91 but is directed towards exit pathway 95. At this point, the release or return pressure between the handles 82 and 84 which is attributable and directly proportional to the release pressure associated with the compression of the drive assembly 70 (explained below) causes the end 92 of flange 83 to settle or lock within a catch basin 93. Handle 82 is now secured in position within handle 84 which, in turn, locks the jaw members 22 and 24 in a closed position against the tissue. The instrument is now positioned for selective application of electro-surgical energy to form the tissue seal 152. Again, the various operating elements and their relevant functions are

explained in more detail with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

As best shown in FIG. 2, re-initiation or re-grasping of the handle 82 again moves flange 83 generally proximally along the newly re-directed exit path 95 until end 92 clears a lip 94 disposed along exit pathway 95. Once lip 94 is sufficiently cleared, handle 82 and flange 83 are fully and freely releasable from handle 84 along exit pathway 95 upon the reduction of grasping pressure which, in turn, returns the jaw members 22 and 24 to the open, pre-activated position.

As mentioned above, the housing and handle assembly 80 houses a drive assembly 70 which cooperates with the movable handle 82 to impart relative movement of the jaw members 22 and 24 to grasp the tissue 150. The operation of the drive rod assembly 70 and the various working components of the drive assembly 70 are explained in detail in the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

Generally and for the purposes of the present disclosure, the drive assembly 70 includes a compression spring 72, a drive rod 40 and a compression sleeve 98 (FIG. 2). As best shown in the enlarged view of FIG. 4, the drive rod 40 is telescopically and internally reciprocable within a knife sleeve 48. Movement of the drive rod 40 relative to the knife sleeve 48 imparts movement to the jaw members 22 and 24. A tab member 46 is disposed at a free end 42 of the drive rod 40 which defines a notch 43 between the tab 46 and end 42. The tab 46 and the notch 43 mechanically cooperate with the compression spring 72 to impart movement of the shaft 40 relative to the knife sleeve 48 which, in turn, opens and closes the jaw members 22 and 24 about the tissue 150.

As explained above, movement of the handle assembly 80 via the four-bar linkage, ultimately causes cam-like link 76 to rotate generally clockwise about pivot 75 (i.e. proximally) which, in turn, compresses spring 72 proximally against a flange 77 disposed within the upper portion of the fixed handle 84. Movement of the spring 72, in turn, moves the drive rod 40 relative to the knife sleeve 48 which moves the opposing jaw members 22 and 24 relative to one another. As can be appreciated, the significant mechanical advantage associated with the four-bar linkage permits facile, consistent and uniform compression of the spring 72 which, in turn, permits facile, consistent and uniform compression of the jaw members 22 and 24 about the tissue 150. Other details and advantages of the four-bar mechanical linkage are more fully discussed with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

Once the tissue 150 is grasped between opposing jaw members 22 and 24, electro-surgical energy can be supplied to the jaw members 22 and 24 through an electro-surgical interface 110 disposed within the handle 84. Again these features are explained in more detail with respect to the above-mentioned commonly assigned, co-pending "VESSEL SEALER AND DIVIDER" application.

Forceps 10 also includes a trigger 86 which reciprocates the knife sleeve 48 which, in turn, reciprocates a knife 60 disposed within the end effector assembly 20 as explained below (FIG. 5). Once the a tissue seal 152 is formed (FIG. 7), the user can activate the trigger 86 to separate the tissue 150 as shown in FIG. 9 along the tissue seal 152. As can be appreciated, the reciprocating knife 60 allows the user to quickly separate the tissue 150 immediately after sealing without substituting a cutting instrument through the cannula or trocar port (not shown). It is envisioned that the knife 60 also facilitates a more accurate separation of the vessel

150 along an ideal cutting plane “B-B” associated with the newly formed tissue seal 152 (See FIGS. 7-9). Knife 60 preferably includes a sharpened edge 62 for severing the tissue 150 held between the jaw members 22 and 24 at the tissue sealing site 152 (FIG. 7). It is envisioned that knife 60 may also be coupled to the electrosurgical energy source to facilitate separation of the tissue 150 along the tissue seal 152.

Preferably and as explained in more detail with respect to the above-mentioned commonly assigned, co-pending “VESSEL SEALER AND DIVIDER” application, handle assembly 80 may also include a lockout mechanism (not shown) which restricts activation of trigger 86 until the jaw members 22 and 24 are closed and/or substantially closed about tissue 150. For example and as best seen in FIG. 2, exit pathway 95 may be dimensioned such that the trigger 86 is only activatable when flange 83 is disposed in a predetermined or predefined position which provides sufficient clearance for the activation of the trigger 86, e.g., seated within catch basin 93. It is envisioned that configuring the handle assembly 80 in this fashion may reduce the chances of premature activation of the trigger 86 prior to electrosurgical activation and sealing.

A rotating assembly 88 may also be incorporated with forceps 10. Preferably, rotating assembly 88 is mechanically associated with the shaft 12 and the drive assembly 70. As seen best in FIG. 4, the shaft 12 includes an aperture 44 located therein which mechanically interfaces a corresponding detent (not shown) affixed to rotating assembly 88 such that rotational movement of the rotating assembly 88 imparts similar rotational movement to the shaft 12 which, in turn, rotates the end effector assembly 20 about a longitudinal axis “A”. These features along with the unique electrical configuration for the transference of electrosurgical energy through the handle assembly 80, the rotating assembly 88 and the drive assembly 70 are described in more detail in the above-mentioned commonly assigned, co-pending “VESSEL SEALER AND DIVIDER” application.

As best seen with respect to FIGS. 3, 5 and 6A-6F, end effector assembly 20 attaches to the distal end 14 of shaft 12. The end effector assembly 20 includes the first jaw member 22, the second jaw member 24 and the reciprocating knife 60 disposed therebetween. The jaw members 22 and 24 are preferably pivotable about a pivot 37 from the open to closed positions upon relative reciprocation, i.e., longitudinal movement, of the drive rod 42 as mentioned above. Again, the mechanical and cooperative relationships with respect to the various moving elements of the end effector assembly 20 are further described with respect to the above-mentioned commonly assigned, co-pending “VESSEL SEALER AND DIVIDER” application.

Each of the jaw members includes an electrically conductive sealing surface 35 disposed on inner-facing surface 34 thereof and an insulator 30 disposed on an outer-facing surface 39 thereof. It is envisioned that the electrically conductive surfaces 35 cooperate to seal tissue 150 held therebetween upon the application of electrosurgical energy. The insulators 30 together with the outer, non-conductive surfaces 39 of the jaw members 22 and 24 are preferably dimensioned to limit and/or reduce many of the known undesirable effects related to tissue sealing, e.g., flashover, thermal spread and stray current dissipation.

It is envisioned that the electrically conductive sealing surfaces 35 may also include a pinch trim which facilitates secure engagement of the electrically conductive surface 35 to the insulator 30 and also simplifies the overall manufac-

turing process. It is envisioned that the electrically conductive sealing surface 35 may also include an outer peripheral edge which has a radius and the insulator 30 meets the electrically conductive sealing surface 35 along an adjoining edge which is generally tangential to the radius and/or meets along the radius. Preferably, at the interface, the electrically conductive surface 35 is raised relative to the insulator 30. These and other envisioned embodiments are discussed in concurrently-filed, co-pending, commonly assigned Application Serial No. PCT/US01/11412 entitled “ELECTROSURGICAL INSTRUMENT WHICH REDUCES COLLATERAL DAMAGE TO ADJACENT TISSUE” by Johnson et al. and concurrently-filed, co-pending, commonly assigned Application Serial No. PCT/US01/11411 entitled “ELECTROSURGICAL INSTRUMENT WHICH IS DESIGNED TO REDUCE THE INCIDENCE OF FLASHOVER” by Johnson et al. The entire contents of both of these applications are hereby incorporated by reference herein.

Preferably, a least one of the electrically conductive surfaces 35 of the jaw members, e.g., 22, includes a longitudinally-oriented channel 36 defined therein which extends from a proximal end 26 to a distal end 28 of the jaw member 22. It is envisioned that the channel 36 facilitates longitudinal reciprocation of the knife 60 along a preferred cutting plane “B-B” to effectively and accurately separate the tissue 150 along the formed tissue seal 152 (See FIGS. 7-9). Preferably and as explained in detail in the above-mentioned commonly assigned, co-pending “VESSEL SEALER AND DIVIDER” application, the jaw members 22 and 24 of the end effector assembly 20 are electrically isolated from one another such that electrosurgical energy can be effectively transferred through the tissue 150 to form seal 152.

As mentioned above, upon movement of the handle 82, the jaw members 22 and 24 close together and grasp tissue 150. At this point flange 83 becomes seated within catch 93 which, together with the mechanical advantage associated with the four-bar mechanism and the spring 70, maintains a proportional axial force on the drive rod 40 which, in turn, maintains a compressive force between opposing jaw members 22 and 24 against the tissue 150. It is envisioned that the end effector assembly 20 may be dimensioned to off-load excessive clamping forces to prevent mechanical failure of certain internal operating elements of the end effector.

By controlling the intensity, frequency and duration of the electrosurgical energy applied to the tissue 150, the user can either cauterize, coagulate/desiccate seal and/or simply reduce or slow bleeding. As mentioned above, two mechanical factors play an important role in determining the resulting thickness of the sealed tissue and effectiveness of the seal, i.e., the pressure applied between opposing jaw members 22 and 24 and the gap distance between the opposing sealing surfaces 35 of the jaw members 22 and 24 during the sealing process. However, thickness of the resulting tissue seal 152 cannot be adequately controlled by force alone. In other words, too much force and the two jaw members 22 and 24 would touch and possibly short resulting in little energy traveling through the tissue 150 thus resulting in a bad tissue seal 152. Too little force and the seal 152 would be too thick.

Applying the correct force is also important for other reasons: to oppose the walls of the vessel; to reduce the tissue impedance to a low enough value that allows enough current through the tissue 150; and to overcome the forces of expansion during tissue heating in addition to contributing towards creating the required end tissue thickness which is an indication of a good seal.

Preferably, the electrically conductive sealing surfaces **35** of the jaw members **22** and **24** are relatively flat to avoid current concentrations at sharp edges and to avoid arcing between high points. In addition and due to the reaction force of the tissue **150** when engaged, jaw members **22** and **24** are preferably manufactured to resist bending. For example and as best seen in FIG. 6A, the jaw members **22** and **24** are preferably tapered along width "W" which is advantageous for two reasons: 1) the taper will apply constant pressure for a constant tissue thickness at parallel; 2) the thicker proximal portion of the jaw members **22** and **24** will resist bending due to the reaction force of the tissue **150**.

As best seen in FIGS. 5-6F, in order to achieve a desired spacing between the electrically conductive surfaces **35** of the respective jaw members **22** and **24**, (i.e., gap distance) and apply a desired force to seal the tissue **150**, at least one jaw member **22** and/or **24** includes at least one stop member, e.g., **50a**, which limits the movement of the two opposing jaw members **22** and **24** relative to one another. Preferably, the stop member, e.g., **50a**, extends from the sealing surface or tissue contacting surface **35** a predetermined distance according to the specific material properties (e.g., compressive strength, thermal expansion, etc.) to yield a consistent and accurate gap distance during sealing. Preferably, the gap distance between opposing sealing surfaces **35** during sealing ranges from about 0.001 inches to about 0.005 inches and, more preferably, between about 0.002 and about 0.003 inches.

Preferably, stop members **50a-50g** are made from an insulative material, e.g., parylene, nylon and/or ceramic and are dimensioned to limit opposing movement of the jaw members **22** and **24** to within the above mentioned gap range. It is envisioned that the stop members **50a-50g** may be disposed on one or both of the jaw members **22** and **24** depending upon a particular purpose or to achieve a particular result.

FIGS. 6A-6F show various contemplated configurations of the non-conductive stop members **50a-50g** disposed on, along or protruding through the jaw member **24**. It is envisioned that one or more stop members, e.g., **50a** and **50g**, can be positioned on either or both jaw members **22** and **24** depending upon a particular purpose or to achieve a desired result. As can be appreciated by the present disclosure, the various configurations of the stop members **50a-50g** are designed to both limit the movement of the tissue **150** prior to and during activation and prevent short circuiting of the jaw members **22** and **24** as the tissue **150** is being compressed.

FIGS. 6A and 6B show one possible configuration of the stop members **50a-50g** for controlling the gap distance between opposing seal surfaces **35**. More particularly, a pair of longitudinally-oriented tab-like stop members **50a** are disposed proximate the center of sealing surface **35** on one side of the knife channel **36** of jaw member **24**. A second stop member, e.g., **50b**, is disposed at the proximal end **26** of jaw member **24** and a third stop member **50g** is disposed at the distal tip **28** of jaw member **24**. Preferably, the stop members **50a-50g** may be configured in any known geometric or polynomial configuration, e.g., triangular, rectangular, circular, ovoid, scalloped, etc., depending upon a particular purpose. Moreover, it is contemplated that any combination of different stop members **50a-50g** may be assembled along the sealing surfaces **35** to achieve a desired gap distance. It is also envisioned that the stop members may be designed as a raised lip (not shown) which projects from the outer periphery of the jaw member **24**.

FIG. 6C shows a first series of circle-like stop members **50c** extending from the proximal end **26** to the distal end **28** of jaw member **24** in an alternating, laterally-offset manner relative to one another on one side of the knife channel **36** and a second series of circle-like stop members **50c** extending from the proximal end **26** to the distal end **28** of jaw member **24** in an alternating, laterally-offset manner relative to one another on the other side of the knife channel **36**. It is envisioned that circle-like stop members **50c** are substantially equal in size, however, one or more of the stop members **50c** may be dimensioned larger or smaller than the other stop members **50c** depending upon a particular purpose or to achieve a desired result.

FIG. 6D shows yet another configuration wherein the stop member is configured as a longitudinally-oriented ridge **50e** extending from a proximal end **26** to a distal end **28** of jaw member **24** along one side of knife channel **36**. As mentioned above, a second longitudinally-oriented ridge **50e** may be disposed on opposing jaw member **22** on the opposite side of knife channel **36** for sealing purposes. FIG. 6E shows a series of elongated tab-like members **50f** which are disposed at an angle relative to knife channel **36**. FIG. 6F shows yet another configuration wherein different stop members, e.g., **50a**, **50c** and **50g** are disposed atop sealing surface **35** on both sides of the knife channel **36**.

Preferably, the non-conductive stop members **50a-50g** are molded onto the jaw members **22** and **24** (e.g., overmolding, injection molding, etc.), stamped onto the jaw members **22** and **24** or deposited (e.g., deposition) onto the jaw members **22** and **24**. The stop members **50a-50g** may also be slideably attached to the jaw members and/or attached to the electrically conductive surfaces **35** in a snap-fit manner. Other techniques involve thermally spraying a ceramic material onto the surface of the jaw member **22** and **24** to form the stop members **50a-50g**. Several thermal spraying techniques are contemplated which involve depositing a broad range of heat resistant and insulative materials on the electrically conductive surfaces **35** to create stop members **50a-50g**, e.g., High velocity Oxy-fuel deposition, plasma deposition, etc.

It is envisioned that the stop members **50a-50g** protrude about 0.001 to about 0.005 inches from the inner-facing surfaces **35** of the jaw members **22** and **24** which, as can be appreciated by the present disclosure, both reduces the possibility of short circuiting between electrically conductive surfaces and enhances the gripping characteristics of the jaw members **22** and **24** during sealing and dividing. Preferably, the stop members **50a-50g** protrude about 0.002 inches to about 0.003 inches from the electrically conductive surface **35** which has been determined yield an ideal gap distance for producing effective, uniform and consistent tissue seals.

Alternatively, the stop members **50a-50g** can be molded onto the inner-facing surface **35** of one or both jaw members **22** and **24** or, in some cases, it may be preferable to adhere the stop member **50a-50g** to the inner facing surfaces **35** of one or both of the jaw members **22** and **24** by any known method of adhesion. Stamping is defined herein to encompass virtually any press operation known in the trade, including but not limited to: blanking, shearing, hot or cold forming, drawing, bending, and coining.

FIGS. 6A-6F show some of the possible configurations of the stop members **50a-50g**, however, these configurations are shown by way of example and should not be construed as limiting. Other stop member configurations are also contemplated which may be equally effective in reduc-

ing the possibility of short circuiting between electrically conductive surfaces **35** and enhancing tissue grip during sealing and dividing.

Further, although it is preferable that the stop members **50a-50g** protrude about 0.001 inches to about 0.005 and preferably about 0.002 inches to about 0.003 inches from the inner-facing surfaces **35** of the jaw member **22** and **24**, in some cases it may be preferable to have the stop members **50a-50g** protrude more or less depending upon a particular purpose. For example, it is contemplated that the type of material used for the stop members **50a-50g** and that material's ability to absorb the large compressive closure forces between jaw members **22** and **24** will vary and, therefore, the overall dimensions of the stop members **50a-50g** may vary as well to produce the desired gap distance.

In other words, the compressive strength of the material along with the desired or ultimate gap distance required for effective sealing are parameters which are carefully considered when forming the stop members **50a-50g** and one material may have to be dimensioned differently from another material to achieve the same gap distance or desired result. For example, the compressive strength of nylon is different from ceramic and, therefore, the nylon material may have to be dimensioned differently, e.g., thicker, to counteract the closing force of the opposing jaw members **22** and **24** and to achieve the same desired gap distance when utilizing a ceramic stop member.

The present disclosure also relates to a method of sealing and dividing tissue and includes the steps of providing an endoscopic bipolar forceps **10** which includes an elongated shaft **12** having opposing jaw members **22** and **24** at a distal end **14** thereof which cooperate to grasp tissue **150** therebetween, at least one non-conductive and spaced-apart stop member **50a-50g** disposed on an inner facing surface **35** of at least one of the jaw members, e.g., **24**, which controls the distance between the jaw members **22** and **24** when tissue **150** is held therebetween, and a knife **60**.

The method further includes the steps of: connecting the jaw members **22** and **24** to a source **110** of electrical energy; actuating the jaw members **22** and **24** to grasp tissue **150** between opposing jaw members **22** and **24**; conducting energy to the jaw members **22** and **24** to through tissue **150** held therebetween to effect a seal **152** (FIGS. 7-9); and actuating the knife **60** to sever tissue proximate the seal **152**.

Preferably, at least one of the jaw members, e.g., **24**, of the providing step includes an electrically conductive surface **35** having a longitudinally-oriented channel **36** defined therein which facilitates actuation of the knife **60** in a longitudinally reciprocating fashion within the channel **36** for severing the tissue **150** proximate the tissue site.

From the foregoing and with reference to the various figure drawings, those skilled in the art will appreciate that certain modifications can also be made to the present disclosure without departing from the scope of the present disclosure. For example, it may be preferable to add other features to the forceps **10**, e.g., an articulating assembly to axially displace the end effector assembly **20** relative to the elongated shaft **12**.

Moreover, it is contemplated that the presently disclosed forceps may include a disposable end effector assembly which is selectively engageable with at least one portion of the electrosurgical instrument, e.g., shaft **12** and/or handle assembly **80**.

While several embodiments of the disclosure have been shown in the drawings, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification

be read likewise. Therefore, the above description should not be construed as limiting, but merely as exemplifications of a preferred embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

What is claimed is:

1. A bipolar electrosurgical instrument, comprising:

a housing;

a shaft extending distally from the housing;

first and second jaw members disposed at a distal end of the shaft, the first and second jaw members including first and second seal surfaces, respectively, the first and second seal surfaces defining first and second knife channels, respectively, at least one of the first or second jaw members movable relative to the other from an open position to a closed position to grasp tissue between the first and second seal surfaces, the first and second seal surfaces adaptable to connect to a source of electrical energy such that the first and second seal surfaces are capable of conducting energy through tissue grasped therebetween;

a drive rod extending from the housing and through the shaft, the drive rod operably coupled with at least one of the first or second jaw members such that proximal translation of the drive rod moves the at least one of the first or second jaw members relative to the other to the closed position;

a drive linkage including at least a first end portion and a second end portion;

a movable handle coupled to the housing and movable proximally relative to a fixed handle portion of the housing from a spaced-apart position to an approximated position, the movable handle pivotably connected to the first end portion of the drive linkage;

a spring disposed within the housing, wherein a first end portion of the spring is operably coupled to the second end portion of drive linkage and wherein a second end portion of the spring is operably coupled to the drive rod, wherein movement of the drive linkage, in response to proximal movement of the movable handle from the spaced-apart position towards the approximated position moves the spring proximally to translate the drive rod proximally to thereby move the at least one of the first or second jaw members relative to the other to the closed position to maintain a compressive force between the first and second jaw members about tissue grasped between the first and second seal surfaces;

at least one stop member disposed on at least one of the first or second jaw members, the at least one stop member configured to regulate a gap distance between the first and second sealing surfaces in the closed position, wherein the gap distance and the compressive force facilitate sealing tissue grasped between the first and second sealing surfaces; and

a knife configured to translate through the first and second knife channels to cut sealed tissue.

2. The bipolar electrosurgical instrument according to claim 1, wherein the movable handle is configured to move the drive linkage to rotate and wherein rotation of the drive link moves the spring.

3. The bipolar electrosurgical instrument according to claim 1, further comprising a ratchet associated with the fixed handle portion of the housing and the movable handle, the ratchet including a flange and a channel, the flange configured to engage the channel upon actuation of the movable handle to lock the movable handle relative to the fixed

## 15

handle portion of the housing, thereby locking the first and second jaw members in the closed position.

4. The bipolar electrosurgical instrument according to claim 1, further comprising a trigger pivotably coupled to the housing and operably coupled to the knife, wherein actuation of the trigger moves translates the knife through the first and second knife channels.

5. The bipolar electrosurgical instrument according to claim 4, further comprising a knife sleeve extending from the housing and through the shaft, the knife sleeve operably coupling the trigger with the knife, wherein actuation of the trigger translates the knife sleeve to thereby translate the knife through the first and second knife channels.

6. The bipolar electrosurgical instrument according to claim 1, wherein the first and second seal surfaces are disposed on inwardly-facing surfaces of the first and second jaw members, respectively, and wherein each of the first and second jaw members further includes an insulator disposed on an outwardly-facing surface thereof.

7. The bipolar electrosurgical instrument according to claim 1, wherein the at least one stop member includes a plurality of stop members.

## 16

8. The bipolar electrosurgical instrument according to claim 1, further comprising a tab extending from the drive rod, wherein movement of the spring urges the spring into the tab to translate the drive rod to thereby move the at least one of the first or second jaw members relative to the other to the closed position.

9. The bipolar electrosurgical instrument according to claim 8, wherein the spring is compressed against the tab to translate the drive rod.

10. The bipolar electrosurgical instrument according to claim 1, wherein the spring is disposed about the drive rod.

11. The bipolar electrosurgical instrument according to claim 10, wherein the spring is a compression coil spring.

12. The bipolar electrosurgical instrument according to claim 10, wherein the spring and the drive rod are aligned on a longitudinal axis extending through the shaft.

13. The bipolar electrosurgical instrument according to claim 1, wherein both of the first and second jaw members are movable from the open position to the closed position.

\* \* \* \* \*